

SIMPLE METHODS FOR TESTING PAINTERS' MATERIALS

A. C. WRIGHT M.A., B.Sc.

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SIMPLE METHODS FOR TESTING PAINTERS' MATERIALS

BY

A. C. WRIGHT, M.A. (OXON.), B.Sc. (LOND.)
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WITH EIGHT ILLUSTRATIONS



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PREFACE.

THE materials employed in painting are, perhaps for several reasons, peculiarly liable to adulteration, and it is not uncommon to find one substance entirely replaced by another of lower value. This book is designed to enable the painter and dealer to test and value the materials they buy, and the manufacturer and dealer the samples submitted to them, in the simplest manner, both in regard to practical properties and composition, the latter term being here used more in a manufacturing than a purely chemical sense.

I have addressed myself throughout to the layman, so that the chemist will find much superfluous matter, but will also, I hope, find

points of interest. I have endeavoured to treat the subject in such a manner that the descriptions might enable any intelligent person to execute all the tests and obtain reliable results. But whilst the descriptions of methods will be found very detailed, I have made no attempt to give any but the most necessary explanations of the chemistry of the processes. I have also dealt only with materials in every-day use, and have given the greatest attention to points of the most practical importance.

Several of the processes described, though they may have been in use, have not, I think, hitherto been published. I trust that these may be found reliable and useful.

A. C. WRIGHT.

March, 1903.

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INTRODUCTION.

1. **Necessity for Testing.**—There are two ways of discovering that a substance employed in the arts and manufactures is not what it is supposed to be. It may be used, when a result differing from the expected will show that some one of the materials employed was deficient in quality; the particular substance which caused the bad result has then to be found, and possibly the work done over again. This method leads to trouble and expense. The alternative method consists in testing every substance before it is used or sold, immediately it comes into the hands of the manufacturer, dealer or consumer. If the testing is efficient, there is then no opportunity for surprises when the materials are employed. The preliminary trouble, and possibly expense, may be greater, but in the long run the economy is considerable. Broadly speaking, it may be said that no one should

use or sell materials, which he buys or makes, without first ascertaining that they satisfy his requirements. The testing may range from a simple inspection to an exhaustive analysis, whichever may be required to elucidate the quality of the substance.

The quality of the materials employed in painting depends, in the first place, on certain practical properties—shade, drying-power, etc.; when these are satisfied it becomes a question of ascertaining by chemical tests whether the substance will fulfil the requirements of durability and permanence, which cannot well be tested in a practical manner on every occasion. The chemical tests are also employed because they show, in a more delicate and precise manner than the practical tests, the presence of adulterants, and thus the true quality and value of the substance.

2. Standards.—Certain properties of the materials, which cannot conveniently be expressed in figures—shade, drying-power—must be estimated by comparison with standards, which are samples of the particular substance chosen as answering all requirements, and to which all future parcels, made or bought, will

be expected to conform. The importance of keeping standards of paints, dry colours, varnishes, etc., cannot be over-estimated. Standards of dry colours may be preserved in lever-lid tins, of paints in collapsible tubes. It is also advisable to keep samples of each delivery of bought materials and each batch of manufactured. The former may probably be destroyed at regular intervals.

3. Arrangement.—The tests to which the ordinary materials used in decorative painting are subjected, in order that an estimate may be obtained of their purity and quality, may be divided roughly into practical and chemical (and physical) methods. This division is adopted here merely for the sake of convenience, and it will be found that methods are included in one section which perhaps should more properly be placed in the other. The “practical methods” relate to those properties of pigments, paints, oils, etc., which are of immediate importance in their application, such as the shade and staining power of paints, the drying of boiled oil, and the durability of varnishes. The chemical and physical methods are designed to elucidate the

actual composition of the various substances, and thus to give an estimate of their value, and consequently of the manner in which they will answer the requirements of practice.

In the first place, the apparatus employed in the different tests will be described, and precise directions given for its use. The practical methods, treated generally, will then follow, and finally the chemical tests for each substance.

4. General Preliminary Instructions.—Before commencing the description of the apparatus, it is thought to be expedient to make certain preliminary remarks of general application:—

1. Before performing any operation, read all the details given concerning it, and if you are not perfectly familiar with the use of the apparatus, refer to that section which describes it. Have everything required for a test ready to hand before you begin.

2. First try all tests on materials whose composition you know (if possible), until you can carry them out in a satisfactory manner, *then* apply the test to the sample whose composition or value you are examining. It

is no waste of time to repeat a test several times until you know exactly how to perform it. Whatever written instruction may be given, ease and rapidity in working can only be attained by practice.

3. Perfect cleanliness is always an absolute necessity. Without cleanliness, doubtful or erroneous results, which may have serious consequences, must occur sooner or later. Given cleanliness and care in working, there follows a just confidence in the results. This condition of cleanliness must be observed in carrying out all tests, practical and chemical. Fortunately, a training in colour-sampling does not lead to laxity in this respect.

4. When a case of adulteration appears to be detected, do not immediately make a charge of fraud, which is a serious matter, and, if there should have been a mistake in testing, might lead to very unpleasant consequences. Generally speaking, it would not be wise to make a charge of fraud except on the evidence of a trained chemist, to whom such cases should be referred, if redress cannot be obtained in some other way.



CHAPTER I.

THE APPARATUS.

5. The Working Place should be set apart for the purpose of testing materials and kept for this purpose only. It should consist of a bench about three feet high, two feet wide and six feet long ; a hard wood or lead-covered top is desirable. A wooden top should be merely oiled, not painted. Beneath the bench should be a cupboard and drawers to hold the apparatus, and store the samples and standards. At one end may be shelves to hold bottles of the necessary reagents. At the other end should be a water-tap and small sink with waste pipe. If these are not provided, a large stone or glass bottle, provided with a tap at the bottom, standing on a shelf about 8 to 10 in. above the bench, may be substituted, and the waste water may be collected in a *wooden* pail placed so that its rim is level with the top of the bench. Of course any regular means of

supplying water *may* be omitted, but the omission will be extremely inconvenient. In this case, as in all others, it will be found advisable to make convenient arrangements at the outset, since the tendency is always to neglect to perform operations the means for which are not at hand. If water is not readily accessible, the apparatus will not be cleaned as often as is necessary (which is whenever it has been used), and mistakes will follow in due course.

A gas supply ending in two $\frac{1}{4}$ or $\frac{3}{8}$ in. nozzles must be provided. The nozzles may be at the back of the bench, about 1 in. above its surface, or they may be underneath it in front, with a corresponding $\frac{3}{4}$ in. hole through the top of the bench to admit the necessary india-rubber tubing. On the whole, the best position for both taps and nozzles is the back of the bench.

The lighting of this working place is most important. The best arrangement is to have a plain or frosted glass window (kept clean), with an uninterrupted north aspect, at the back of the bench. If this cannot be obtained, the window should be so placed as to receive as little direct sunlight as possible. It is almost

as difficult to match and test colours in strong sunlight as in semi-darkness. Means for screening sunlight from the window should be provided. Most forms of artificial lighting have their disadvantages ; perhaps the best of the ordinary sources of light is the incandescent gaslight.



FIG. 1.

6. Colour and Paint Sampling Apparatus.—For sampling dry colours, small palette knives (4 or 5 in.) are most convenient ; they must be kept perfectly clean and smooth by means of bath-brick or other similar material. For paints 6 and 7 in. knives may be required, and, occasionally, larger sizes. A stout 6 in. knife, ground down on the grindstone, so that it tapers from the original width near the handle to about $\frac{1}{4}$ in. at the point (see Fig. 1), is very useful. The metal must not be reduced in thickness in the grind-

ing. This taper knife enables quite small, but sufficient, quantities of colour to be ground in oil, and thus leads to economy in time and material.

For most purposes paints may be sampled

on white marble slabs or white glazed earthenware tiles. A large slab and muller will be required for grinding hard substances (siennas, ochres, etc.) in oil. A small hand paint-mill may also be useful.

An oil bottle provided with a dropping tube is required. Take a piece of glass tubing (about $\frac{1}{4}$ in. wide), make a notch with a triangular file at one side of the tube (*not* all round) about 2 in. from the end, hold the tube in the fingers, with one hand at each side of the notch, and close to it, then snap the tube ; the end will thus be cut off square. In the same manner then cut off a piece about 12 in. long, hold this horizontally over the flame of the Bunsen burner (par. 12) until it is heated, then bring it into the flame near the top, so that the tube is heated about 3 in. from one end. Keep the tube slowly revolving in the fingers until the glass softens and begins to fall in, then slowly draw out the tube, so that the drawn out portion is 2 to 3 in. long. Remove from the flame, continue to hold in the fingers until the glass is hard, then put aside to cool. When cold, cut the tube (as before) with the file in the middle of the con-

stricted portion, then hold each end of the long tube in turn in the flame, with the tube nearly vertical, until the glass at the end just softens and the narrow end forms quite a small orifice. This tube may then be used for delivering a certain number of drops of oil to a dry colour or paint on the tile. If the finger is just moistened and held on the upper end it is easy to regulate the number of drops which fall from the narrow end.

Small tins, ranging in size upwards from 2 in. deep and $1\frac{1}{2}$ in. wide, may be used for mixing liquid paints, etc. The paint is mixed up in these by means of a palette knife or stout iron wire hammered out flat at the end. Liquid paints, lacquers, etc., are put to dry on strips of tin, which may be obtained from tinnings' waste, and may be used in almost any size from $2\frac{1}{2}$ by $1\frac{1}{2}$ in. upwards. Strips of glass, about 3 to 4 in. wide, are very convenient for the drying tests of varnishes and oils. Whilst the tin would be thrown away after use, the glass strips should be put to soak in strong soda, then very thoroughly washed and dried before being again used.

The stone slabs, earthenware tiles and mix-

ing tins should be cleaned by means of cotton waste and turpentine. The cleaning is very much easier of accomplishment if the paints are never allowed to remain on the articles longer than is absolutely necessary.

7. **The Scales.**—There will be required an ordinary pair of scales, capable of weighing up to 4 lb., with the corresponding set of weights ; no further description is needed here. In addition, an accurate balance, capable of weighing to 0.001 gram (1 milligram), and of carrying 50 grams in each pan, with the pans movable, is necessary. It is much better to purchase a balance provided with a glass case, which protects it from dust and damp. If a glass case is not provided, the balance should be covered with a tin case when not in use. A suitable balance, with a glass case, can be purchased from any dealer in chemical apparatus for about fifty shillings. This balance must be placed on a firm support, where it is not shaken by persons walking across the floor of the room. A very good position is a shelf fixed to a wall ; this is, of course, not suitable if the wall is shaken by machinery. The balance will only weigh accurately if the cen-

tral pillar is strictly vertical, *i.e.*, when the beam is horizontal, the pointer must be at the centre of the scale. This condition is generally obtained by making the base-board horizontal, which is done by means of the levelling screws, L, under the balance case and a spirit level.

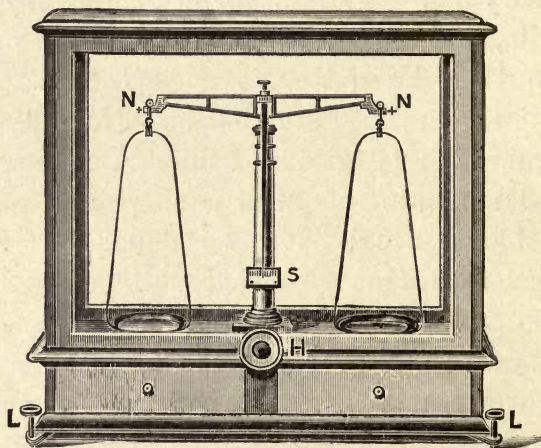


FIG. 2.

The screws must be adjusted so that the spirit level shows the base-board to be level from side to side, and also from back to front. If the balance is not provided with levelling screws, it must be made horizontal in some other manner (by wedging up), and then fixed. When once fixed and adjusted, a balance is

not lightly to be disturbed. Some means is always provided for correcting the balance when it is out of adjustment, *i.e.*, when the pointer does not give equal swings on each side of the scale whilst there are equal weights in the two pans. This means of adjustment, in a balance of the type mentioned here, generally takes the form of small nuts, N, on screws at each end of the beam. When the base-board has been fixed in a horizontal position, and the scale pans and beam carefully dusted, turn the handle or screw, H, at the foot of the pillar, which lifts up the beam on the central knife edge, and thus sets it swinging. Note the number of divisions on each side of the centre of the scale, S, to which the pointer swings. If it swings to the same extent on each side, the balance is in correct adjustment. This will not generally be the case when the balance is first set up. The side of the balance to which the pointer swings further is the lighter, therefore screw out a little further the nut on the screw at that end of the beam. Set the balance swinging again, note the extent of the swing on each side, and continue to move the nut until the

pointer swings exactly to the same extent on each side. Screwing out the nut on one end of the beam gives the same result as screwing in the nut at the other end. From time to time the balance will require cleaning; take it apart, dust it carefully, then replace the parts and adjust as above described. Never put anything on the pans, or take anything off, without first stopping the motion of the balance by turning the screw at the base of the pillar, in order to bring the beam on to its supports. In weighing, the weights on each pan are equal when the pointer swings to the same extent on each side of the scale.

8. Weights.—The metric system of weights and measures is now used for scientific purposes, whilst the older British systems are still employed in commerce. It matters little which system is employed in the operations to be described in this book. The writer finds it convenient, as a rule, to use the metric weights and measures for operations conducted on a small scale, but avoirdupois weights and the ordinary fluid measure for operations on a larger scale. Thus there are required: a set of gram weights; a box containing the follow-

ing is suitable : 50, 20, 10, 10, 5, 2, 1, 1, 0·5, 0·2, 0·1, 0·1, 0·05, 0·02, 0·01, 0·01 gram ; a set of avoirdupois weights from 2 lb. down to $\frac{1}{4}$ oz. For the gram weights may be substituted a set of grain weights containing the following : 100, 50, 20, 10, 10, 5, 2, 1, 1, 0·5, 0·2, 0·1, 0·1. It may occasionally be necessary to convert grams to grains and *vice versâ* ; the following relations between the two systems may be employed :—

$$1 \text{ gram} = 15\cdot43 \text{ grains.}$$

$$1 \text{ grain} = 0\cdot0648 \text{ gram.}$$

$$1 \text{ avoirdupois ounce} = 28\cdot29 \text{ grams.}$$

In order to preserve the accuracy of a set of delicate weights, and to use them without error, it is necessary to observe certain precautions : In weighing an object of unknown weight, put the weights on the scale pan in their proper order, beginning with the highest ; as a rule, do not try to find short cuts. Always return each weight to its proper place in the box ; if you do not, the next time the weights are required, you are liable to put the wrong ones on the scale pan. No weight should ever be put down on the table, it may only be on the scale pan, in its proper place

in the box, or in the act of being moved from the one to the other. Always pick up weights with the pincers provided in the box, and never with the fingers.

9. **Measures.**—The fluid measures required are 2 oz. and 1 oz. conical glass measures of the ordinary druggists' pattern (Fig. 3) and 100 c.c. and 10 c.c. measures of the cylindrical form



FIG. 3.



FIG. 4.

(Fig. 4). When most liquids are put in glass vessels, they rise up the sides to a certain extent, so that the level of the liquid is higher on the walls than in the centre of the vessel. In using a measure there might therefore be uncertainty as to which portion of the surface is to be brought into line with the division on the measure; the *lowest* por-

tion of the surface, seen on looking horizontally at the measure, is to be brought into line with the division marked on the measure. For certain purposes, in which small quantities of liquid have to be measured and added in succession to another liquid, a *burette* is the best instrument to use. A burette is a long glass tube, provided with a tap at the bottom, and graduated downward from the top. A 50 c.c. burette divided into two-tenths of a c.c. would be suitable for our purpose; to support it a stand with a clamp would be desirable. The burette is used as follows: it is washed out with water, allowing the water to drain out thoroughly, then washed out with a little of the liquid which is to be used in it, which is also allowed to drain out. It is then filled, the liquid given time to run down the walls, and its position in the tube noted (remembering that the graduations run downward). The liquid is then run off through the tap for the purpose required, and finally the level of the liquid again noted; from the difference in the two levels the quantity of liquid used is found.

10. **Thermometers.**—For the purposes of the present book, thermometers on Fahrenheit's

scale are most suitable ; there will be necessary one instrument with a scale going up to 220° F. and a second with a scale up to 600° F. The form of thermometer with a milk-glass back and the scale engraved on the stem is the best. Thermometers must never be heated to a temperature higher than that to which they are graduated. Before using a thermometer, it is well to see that the thread of mercury is intact and not broken up into two or more portions ; if that should be the case the thread can generally be united by placing the thermometer upright and tapping the bulb on the table, or by holding the thermometer by the top and swinging it smartly through the air, though the tube sometimes snaps under this treatment. If a centigrade thermometer is used, it may be necessary to convert the readings to Fahrenheit's scale ; this conversion and the reverse are accomplished by means of the following formulæ :—

$$\begin{aligned} (^{\circ}\text{F} - 32) \times \frac{5}{9} &= ^{\circ}\text{C}. \\ ^{\circ}\text{C} \times \frac{9}{5} + 32 &= \text{°F} \end{aligned}$$

These formulæ may be expressed in words : To convert temperatures on the Fahrenheit scale to the centigrade scale, subtract 32,

multiply by 5 and divide by 9; to convert temperatures on the centigrade scale to the Fahrenheit scale, multiply by 9, divide by 5 and add 32.

11. Specific Gravity Apparatus.—The hydrometer and specific gravity bottle, together with the methods by which they are used, are described in a later place (pars. 74 and 75).

12. The Bunsen Burner supplies the flame in which ordinary operations involving heating are conducted. The burner consists of a brass tube standing on an iron foot; the gas enters by a side tube at the bottom and then passes into a narrow tube inside the main tube. At the bottom of the burner is a sliding regulator by which the supply of air to the burner can be adjusted. This air mixes with the gas in the tube, and the mixture burns with a blue (“non-luminous”) flame, if the supply of air is properly adjusted. When the air supply is cut off, the gas burns with the ordinary flame, which deposits soot on a cold object heated in it. When the gas is turned on full, the air-holes generally require to be fully open to admit sufficient air, but when the gas is turned down to give a small flame too much air is

admitted, which may cause the burner to "strike back," *i.e.*, the gas may burn first at the end of the narrow tube at the bottom of the main tube; when this happens a gas (acetylene) of very disagreeable odour is formed and the burner sometimes whistles. This "striking back" when using a small flame may be prevented by partially turning off the air supply, until a little less air would make the flame luminous. When a Bunsen burner is first lighted, it frequently "strikes back," but will not do so if the light is not applied until the air has been driven out of the pipe.

The hottest portions of the Bunsen flame are the outside and the extreme top, consequently test tubes are to be heated in the top of the flame and platinum wires in the outside.

13. Flasks. — The ordinary flat-bottomed shape is required, in the 8 and 16 oz. sizes, with one or two of a large size if large volumes of the reagents are to be made up at once.

14. Bottles.—It is necessary to use glass-stoppered bottles for many of the reagents—acids and alkalis—and advisable to use them

for all. The 10 oz. narrow-mouth bottle is convenient for the ordinary reagents. The bottles for acids, ammonia and caustic soda should have some form of indestructible label, such as the sand-blasted label (made more visible by blackleading); the labels of the other bottles may be written in Indian ink, sized and varnished. In taking up a bottle for use, do not lay the stopper down on the table; if you do, it will be dirtied and the various bottles may get their stoppers exchanged, which of course leads to the contents being spoiled (also the stoppers of bottles of the same size are not interchangeable). Hold the stopper in the hand until the bottle is finished with, then replace the stopper and put the bottle away.

Strong acids and ammonia will naturally be kept in the large bottles in which they are bought (generally Winchester quarts) and the small bottles, from which the reagent is actually used, will be filled from the stock bottles when necessary. It also saves a great deal of time and trouble to make up stock bottles of dilute acids, caustic soda and the other reagents. Oils, varnishes,

etc., are best kept in the ordinary tin bottles.

15. Beakers are thin glass vessels, generally cylindrical, in which liquids are heated. The tall shape without spout is the best for our purpose, the sizes required are 3 oz. and the intermediate capacities to 10 oz. Since beakers are fragile, it is well to commence with some stock, say three "nests" of the sizes given. If stock bottles (Winchester quarts) of dilute acids are made up, beakers of about 90 oz. capacity will be required.

16. Evaporating basins are thin porcelain dishes glazed inside and out. The size we require is No. 00 or 0.

17. Test Tubes.—The most convenient sizes are $6 \times \frac{3}{4}$ and $5 \times \frac{5}{8}$. It will be found advisable to procure half a gross of each size. For cleaning a tube a brush is necessary, and a holder is desirable. A holder may be extemporised from a piece of paper folded to several thicknesses, placed tightly round the tube, and held by the ends. A test-tube stand is required to hold the tubes which are in use. The proper use of test tubes is not at once apparent to the beginner. As a rule the tube

should not be more than one-half filled with liquid, and one-third is better, and it should be held in a slanting position, as shown in the figure (Fig. 5), with only the bottom of the tube in the flame, which should be quite small (3 to 4 in. high), and should on no account be allowed to touch the part of the tube above

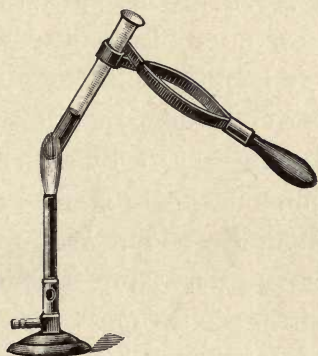


FIG. 5.

the liquid. The "bumping," which often occurs during boiling, may be diminished by shaking the tube, so that any powder at the bottom is shaken up into the liquid. When a dry powder has been put in a tube and then a liquid, the tube should not be heated until all the powder has been wetted by the liquid (which may take some time)

and it has been prevented from forming a solid cake at the bottom. When heating a liquid in a test tube, do not point the mouth of the tube towards yourself or any person near, but point it away to the right.

18. Watch Glasses are used to cover beakers ; the 2 in. and 3 in. sizes are requisite.

19. Glass Rods are employed for stirring oils, varnishes, etc. Take a piece of fairly stout glass rod, cut it into lengths of about 7 in. by making a deep notch with the file and then breaking across by a jerk. Trim off any projection on the broken end by means of the file, hold the rod nearly upright above the top of a Bunsen flame, turning it round slowly until it has had time to be heated, then lower the end of the rod into the flame, *keeping it at the top*, and turn it round slowly until the end becomes red hot, and the sharp edge fuses. A rounded end is thus obtained. Repeat with the other end of the rod.

20. Platinum Wire.—The best size to use is No. 32 B. W. G. Take a piece of narrow glass tube 6 in. long, warm it above the Bunsen flame, and then heat it in the top of the flame until it softens and begins to fall together,

then draw it out slowly, so that the constricted portion is about 2 in. long. Remove from the flame, and when the glass has hardened put it down to cool. When quite cold file the middle of the narrow portion and break by a jerk. Cut a piece of platinum wire 3 in. long, insert it in the narrow end of one of the glass tubes thus made, then, holding the wire in one hand and the glass tube in the other, heat the end of the narrow portion of the tube until it melts round and fastens the wire, then let cool. The tests in which platinum wire is used are extremely useful, but they must be performed with care and patience if the indications are to be reliable. These tests depend on the fact that many volatile metallic compounds impart peculiar colours to the Bunsen flame, which colours are characteristic of the metal in the compound. Now many metallic compounds which are tested in this manner are not volatile at the temperature of the flame and do not form volatile compounds in the flame, which is therefore not coloured by them. The volatile compound required to give the colouration is obtained by heating the substance with hydrochloric

acid. After this explanation the following directions for performing the tests will appear plain :—

First clean the platinum wire by dipping the end in strong hydrochloric acid and holding it in the flame. The wire is to be held in the outside of the flame at a point about half-way up ; the wire itself must appear intensely hot. Continue to dip the wire in hydrochloric acid and heat in the flame until no colouration is imparted ; a momentary flash of yellow, due to the ever-present sodium, may be disregarded. When the wire is clean, dip it in strong hydrochloric acid and then touch with it the powder to be tested ; only a very small quantity of the substance is required on the wire, not more than one or two grains of the powder. If a larger quantity is used, there may be difficulty in cleaning the wire afterwards. Heat the wire in the flame at the spot described above and note the colouration ; if only a yellow colouration is obtained, again dip in acid and heat. Always continue this process of dipping in acid and heating until the expected colouration is obtained, or until the flame is not coloured

at all, in which case the expected substance is not present. To clean the wire, scrape off any large adherent particles, dip in hydrochloric acid and heat, as above, until the wire gives no colouration when dipped and heated. A wire which is difficult to clean may generally be burnt clean by supporting it in such a manner that it can be heated in the flame (at the top) for a long period. When a mixture of two substances, both of which give flame colourations, is heated on platinum wire, the colouration due to one may appear first, and that due to the other when the first has burnt off; this is the case with mixtures of white lead and barytes—the bluish lead flame is seen first and afterwards the pale green barytes flame (after dipping in hydrochloric acid). In the case of other mixtures the flame may be mainly of one colour with occasional flashes of another, *e.g.*, mixtures of white lead and Paris white or terra alba.

21. Tripod Stands and Wire Gauze.—When beakers and flasks are heated they are placed on squares of wire gauze supported on a tripod stand, and the flame placed beneath.

The tripods should be 8 in. high. The pieces of iron wire gauze are 5 or 6 in. square. Squares of gauze are now made with the middle filled in by an asbestos composition; the first cost is somewhat greater than that of the plain gauze, but they last many times longer and are more convenient in use. When a flask or beaker is being heated on wire gauze, the flame should be so regulated that it does not come through the gauze and play round the glass.

22. **India-rubber Tubing** is used for connecting the Bunsen burner to the gas nozzle and for other similar purposes. Black tubing, $\frac{1}{4}$ in. in diameter, is the most suitable. The tubing strengthened by a wire spiral inside is not to be recommended. India-rubber tubing should never be bent at a sharp angle; to do so causes a kink and spoils the length. When tubing is put away it should either lie straight or in a proper coil.

23. **A Mouth Blowpipe** is recommended in a subsequent chapter as affording an easy method of obtaining the tiny flame required in taking flash points. The cheap tin form is suitable.

24. **Filter Funnels and Filter Paper.**—Liquids

are filtered by running them through a folded filter paper placed inside a glass funnel. The most convenient sizes of funnels are 3 in. and 4 in., the former for ordinary purposes and small quantities of liquids, the latter for larger quantities, such as the solutions of the reagents. The corresponding sizes of filter paper are 11 cm. and $18\frac{1}{2}$ cm.; a suitable quality is Schleicher and Schüll's No. 595, which is stocked by most dealers in chemical apparatus. The filter paper is folded first into half and then again in half; this should be done accurately and the fold pressed down. The folded paper is then taken up with three thicknesses to one side and fitted into the funnel.

25. Cleaning Glass Apparatus.—Apparatus of all kinds should be cleaned as soon as possible and not put away dirty; the sooner it is cleaned the easier the operation. Apparatus which has been used with watery liquids should be well rinsed in a strong stream of water, which may alone be sufficient; then a tube brush may be used, and water again. It is often much easier to remove dirt from glass apparatus by means of a little strong hydrochloric or nitric acid. Apparatus which has

contained oil or varnish should be cleaned as far as possible with turpentine and cotton waste and dried with a duster. This is sufficient if it is again to be used with oils or varnishes, but if it is to be used with watery liquids a little strong sulphuric acid (see par. 29) should then be carefully passed round the inside of the vessel, poured out and the vessel next washed out with water. Apparatus which has been used with spirit varnishes must be cleaned with methylated spirit and dried. It is to be observed that, unless apparatus is required dry, it had better be left wet, since water is generally cleaner than a duster. A *regular* supply of clean cloths (dusters) for drying apparatus is most desirable.

26. Cost.—It is not possible to give any definite estimate of the cost of this apparatus, much depends on the scope of the operations to be conducted. In many cases probably much of the apparatus is already available.

CHAPTER II.

THE REAGENTS.

27.—The term “reagent” is usually understood to mean a chemical compound, or solution of a compound, employed in performing an analytical test in such a manner that the compound takes part in the chemical change on which the test is based. The term is here employed in a somewhat wider sense and is taken to include all the materials, other than apparatus, used in performing the operations described in the succeeding chapters.

28. **Water.**—Ordinary water as obtained from the usual sources of supply contains in solution certain substances which render it unfit for universal use in chemical operations. In nearly every test included in the scheme of this book tap water may be used, but more pure water is necessary in certain cases. Several of the tests cannot be properly performed with tap water; in describing these

tests it will be stated that distilled water must be used, and it is to be definitely understood that this instruction cannot be neglected. In place of distilled water we may use clean rain water or the condensed water, which is (or can be) produced in most works in quantity. For the purposes here described condensed water may be used if it does not turn cloudy on long boiling and if it gives a perfectly clear solution when a small piece of caustic potash is dissolved in it by heating.

29. Sulphuric Acid.—Pure sulphuric acid is to be used, not oil of vitriol. It may not be altogether out of place to mention the corrosive action of this and the other strong acids. They must not be allowed to come in contact with the skin or clothes ; any acid which may get on the fingers is to be washed off at once, it is useless to try to wipe it off. (It is stated to be better first to wipe off strong sulphuric acid and then wash ; the writer cannot speak from experience of this course, but whatever is done must be done very quickly to avoid a nasty burn.) Great care is necessary in mixing water with strong sulphuric acid, since the mixture becomes very hot. Hot acid and water or cold

acid and hot water must never be mixed under any circumstances.

Dilute sulphuric acid is made by pouring slowly, in a thin stream, 2 fluid oz. of the strong acid into 8 fluid oz. of water contained in a glass beaker, whilst stirring vigorously with a glass rod. The corresponding larger quantity required for a stock bottle may be made in a large (90 oz.) beaker. The dilute acid is to be allowed to cool, and poured off, leaving any sediment, into the bottle.

30. Nitric Acid.—Ordinary pure nitric acid is required.

31. Hydrochloric Acid.—The ordinary pure concentrated hydrochloric acid is required. The dilute acid is obtained by mixing 1 volume of the strong acid with 4 volumes of water.

32. Acetic Acid may be purchased either in the form of glacial acetic acid or of concentrated acid (33 per cent.). The former is to be diluted with 9 volumes of water, the latter with about $2\frac{1}{2}$ volumes, in order to give the dilute acetic acid of roughly 10 per cent. strength, which we use.

33. Ammonia.—Strong ammonia is the ordinary 880 ammonia, which is diluted with

twice its volume of water to give dilute ammonia.

34. Caustic Soda may be the ordinary pure commercial article (known as 76-77 per cent.). It is somewhat more convenient to use the sticks, which are sold in 1 lb. bottles. The 5 per cent. solution which we use is made by warming (not boiling) 10 oz. of water in a flask or beaker, and then putting in $\frac{1}{2}$ oz. of the solid caustic soda; if it does not dissolve in a few minutes, the action may be accelerated by heating and stirring. The solution is then to be allowed to stand for twenty-four hours until it is quite clear, and the clear liquid poured off from the deposit into the bottle. On account of this deposit, which is formed when the solution is first made, and which continues to form for some time, it is most advisable to make up a stock bottle of the solution, from which the clear liquid can be taken to fill the small bottle as required.

35. Sodium is a soft, silvery metal, which can be cut with the knife. The freshly cut surface tarnishes immediately. Sodium is preserved from the action of the moisture in the air by keeping it under naphtha. It must

never be brought into contact with water, and must be used with the precautions given in the footnote to par. 137.

36. Caustic Potash.—Pure caustic potash in sticks is to be used. The bottle must be well closed, and when a stick is taken out for use, the portions which are swollen and appear white and powdery on the surface are to be rejected. The only test for which caustic potash is used in this scheme requires a very small quantity at a time ; it is inadvisable to return to the bottle any portion which has been exposed to the air for more than a minute or two.

37. Potassium Iodide in Solution is made by shaking 1 oz. of the crystals with 9 oz. of water ; it is not advisable to make a large quantity at a time.

38. Lead Acetate Solution.—Dissolve 1 oz. of lead acetate (white sugar of lead) in 9 oz. of hot water, let it stand until clear and pour off the clear solution into the bottle, or filter.

39. Potassium Ferrocyanide (Yellow Prussiate) Solution.—Dissolve 1 oz. of yellow prussiate of potash in 9 oz. of hot water.

40. Lime Water.—Slake 2 or 3 oz. of clean

quicklime by putting it in a dish and adding water in small quantities, as it is absorbed, until finally the lumps fall to a powder. Transfer the powder to a Winchester quart bottle, fill up with water, shake well, and allow to stand until clear. Then use the clear solution from the top.

41. Uranium Acetate Solution.—Dissolve $\frac{1}{4}$ oz. of uranium acetate in 10 oz. of water. Keep the solution in the dark.

42. Absolute Alcohol is pure spirits of wine practically free from water. It is not used when the much cheaper methylated spirit suffices; in the one or two tests in which it is prescribed for use, methylated spirit cannot well be used.

43. Methylated Spirit.—Manufacturers and laboratories are permitted to use (under restrictions) methylated spirit not containing the small quantity of petroleum which is added to the methylated spirit sold retail. The former is the better to use for our purpose, but the latter will do; it becomes turbid when mixed with water, a fact which must be remembered.

44. Rectified Benzol is the substance which is known scientifically as benzene, and is not

to be confounded with the benzine obtained from petroleum. It is an inflammable liquid and must be used with care. The purpose for which we shall employ benzol is to dissolve oils and varnishes. It may not be out of place to mention that benzol is very useful for removing oil and grease spots from clothes.

45. **Ether.**—There are several qualities of ether sold, the best of which for our purpose is the methylated ether of specific gravity 0.720; the substance of specific gravity 0.730 is slightly cheaper, but is not nearly as convenient. The purpose for which ether is to be used is to extract the oil from paints. Ether is a liquid with a very low boiling point; it evolves a very inflammable vapour at the ordinary temperature. It must therefore be kept in a cool place, not exposed to sunlight; all operations in which it is used must take place at a considerable distance from a flame of any kind; and all vessels in which it is placed must be similarly deposited and must be covered over to prevent evaporation.

46. **Aniline Oil.**—The colourless oil is required; it must be kept in a well-stoppered bottle in the dark. If exposed to the action

of air and light it oxidises and turns very dark, when it becomes unsuitable for our purpose.

47. **Refined Linseed Oil** is to be the ordinary genuine oil, as pale as can be obtained.

48. **Terebine and Quick Goldsize** are to be the usual materials of good quality. The latter should dry in about two hours.

49. **Alkali Blue** is a blue dye, which is soluble in spirit. The solution is turned red by alkalis, and the blue colour is restored by acids. Thus it may be used to detect and measure the presence of abnormal quantities of acid resins (rosin, etc.) in varnishes.

CHAPTER III.

PRACTICAL TESTS.

DRY COLOURS.

50. **Shade.**—In order to compare with precision the shades of any two substances, surfaces of a similar nature must be seen near together. In the case of dry colours this is accomplished as follows : place near together on a sheet of paper little oblong heaps of the two colours, then pass a palette knife with a gentle pressure over the heaps, so that the two acquire one flat surface. The two colours are now seen side by side, and differences in shade and intensity may be exactly gauged.

The importance of preserving samples of all substances bought or produced has been already urged, and the necessity of adopting a certain parcel as a standard, to which all subsequent parcels (bought or made) will be required to correspond. Now, in the vast majority of cases, a fresh sample of colour

is to be compared with this standard. It must be at once pointed out that frequently it matters little to a consumer whether a parcel of dry colour corresponds exactly to his standard. The manufacturer naturally wishes to turn out his colour exactly uniform in shade as seen by the simplest method of examination, which is in the dry state as given above. But what is vastly more important to the consumer is that the dry colour should match the standard sample after both have been mixed in the medium in which they are to be used. Two colours, which are a perfect match when dry, may be utterly different when ground in oil. Therefore the *essential* test is that conducted in the particular medium—size, oil, varnish, turpentine—in which the colour is intended to be used. It may be stated broadly that oil, turpentine and varnish will affect colours in the same manner, and consequently that the difference between any two colours, when both are ground in any one of these media, will be the same, whether oil, turpentine or varnish be used. Turpentine evaporates rapidly, varnish dries and is then not too readily removed from the implements

employed, so that it is most convenient to test by grinding in oil, for which purpose refined linseed oil is most suitable.

51.—If the colour is in fine powder we may proceed as follows :—

Place 3 to 4 grains ($\cdot 02$ gram) of the standard on the white tile, plate of glass, or stone slab, add 1 or 2 drops of oil, and grind with the palette knife (the taper knife (par. 6) is best for these small quantities, an ordinary 6 in. knife for larger) until the mixture is perfectly homogeneous. The consistency of the paste should be rather thicker than that of ordinary liquid paint. It is not advisable to attempt to compare very stiff pastes, and very thin pastes are not easily manipulated ; if, however, the colour is very poor and coarse in body, it may be necessary to use a stiff paste. Add more oil or dry colour until the consistency is suitable. Repeat the process with the sample to be tested, take up a portion of each paste in turn on the narrow knife and transfer them to the tile at the edge, so that the two dabs of paint almost touch, then move the knife over the two dabs of paint so that they are made to join without mixing. The knife removes

superfluous paint, leaving two flat surfaces Fig. 6), in which slight differences of shades and intensity can readily be gauged. Differences in shade are sometimes much more easily perceived if the mixtures are transferred to a piece of *thin* glass in the manner just described, and the two then viewed through the glass. Any uncertainty due to dissimi-

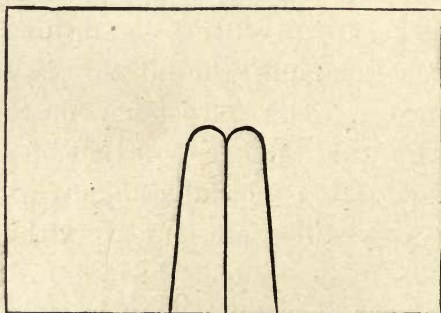


FIG. 6.

larity in the surfaces of the two paints is thus eliminated. It is generally of great importance that the two mixtures of colour and oil should be of exactly the same consistency; certain greens, for example, show very different shades according to the amount of oil with which they are mixed. The requisite equality in consistency can with some practice be obtained with-

out trouble ; the beginner is recommended to weigh the dry colours and use the same number of drops of oil to each.

The process thus described would entirely fail to reveal the true shade of certain very hard colours—siennas, ochres, etc.—which had not been finely ground. Therefore, if it is intended to grind these particular colours before they are used, they must also be thoroughly ground before they are tested. This may be done by means of the slab and muller in the usual manner, or even by prolonged grinding on a stone slab by means of a stiff palette knife. The paints so obtained must then be thinned down to the proper consistency for testing.

In all these operations the greatest cleanliness must be observed : all the implements must be perfectly clean, the knives must be wiped before being transferred from one colour to the other.

It is unnecessary to test by grinding in size those colours which are to be used in distemper work ; the difference between two samples, when examined dry, is the same as the difference after they have been ground in

size and allowed to dry on some white surface, such as paper.

52. Staining Power.—The extent to which a colour or paint can tint a white pigment is known as the staining power ; it really gives a practical measure of the amount of the true colouring principle in the colour in question, of which but a vague estimate is furnished by the depth of tint. Thus when a colour is to be used for tinting purposes, and also when it is desired to make or buy a colour of the same *quality* as the standard sample, it is always necessary to make a comparison of its staining power. This may be done by grinding in a mortar some weight of the colour with (say) five times its weight of white lead and then comparing the depth of the two tints produced ; the method is, however, unsatisfactory, because the shade depends on the amount of grinding, and also because the shades should be compared after grinding in oil, if the colour is to be used in that medium, which is probable. The method given in the next paragraph is much more accurate and far easier to perform.

Weigh very carefully (see par. 7) 0·2 gram

of the colour and 1 gram of dry ground white lead, transfer both completely from the scale pan to the white tile or glass plate, then add, by means of the dropping tube in the oil bottle, 5 drops of oil, mix and grind thoroughly with the palette knife, taking care that no particles escape unground. Repeat this process with the standard and compare the shade produced as described in par. 51. Certain observations must now be made in regard to this process. The same quantity of oil must be used for all samples which are to be compared with one another. Voluminous colours (Prussian blue, blacks, lakes, etc.) require more oil than the five drops ; sufficient must be added to give a suitable consistency (see par. 51), but always the same quantity to both type and sample. It is a sure sign of an essential difference in composition if different quantities of oil are required to give the same consistency. If the shades produced by the two samples are very different in character, it is not easy to judge of the relative staining powers ; the character of the shade is of great importance in the case of colours used as stainers. Zinc oxide may be used in place of white lead. In testing colours

of very great staining power, it is advisable to use much more white lead (say 5 grams); the object is to obtain tints of a depth at which differences are easily perceptible. It is useless to endeavour to test the staining power of colours which are so hard that they cannot be ground fine under the conditions given.

Just as the relative staining powers of two samples of colours are compared by mixing each with the same white pigment, so the quality or reducing power of two white pigments may be compared by grinding each with the same colour. It is well known that the cheaper qualities of white lead and white zinc are obtained by admixtures of barytes and other ground minerals; the latter have far less reducing power than the white lead and white zinc. Thus, if equal weights of pure white lead and white lead adulterated with barytes be ground with the same weight of (say) carbon black, the adulterated lead will produce a deeper shade than the pure lead. The operation is conducted exactly as described in the previous paragraph. It is convenient for this purpose to keep a well ground mixture of 1 part of carbon black with 10 parts

of white zinc, then in the test 0·2 gram of this mixture is weighed out, 1 gram of the white pigment added, and the two ground together with six drops of oil. If the carbon black was not previously diluted with white zinc, an inconveniently large portion of the white pigment would have to be taken in order to produce a shade of the proper intensity.

53. Covering Power.—Paint is generally required to hide or cover the colour of the surface to which it is applied; the extent to which it accomplishes this is known as the “covering power” or “body” of the paint. In everyday practice it is not often that the covering powers of two dry colours have to be compared, the covering powers of paints are more frequently in question; however, it is convenient to give a method at this point. A process to be of value must represent the actual practical conditions. Take two boards of equal size, about 1 foot square; give each two or three coats of white lead ground in turpentine, mixed with turpentine and a little pale goldsize or flatting varnish, rubbing down each coat with sandpaper. The two boards will then be evenly coated and have

surfaces of the same roughness. Now mix two small pots of paint, using the two stiff paints which have to be compared, and take care to weigh or measure *exactly* the same quantities of paint, driers, oil and turpentine for each pot. Apply a coat of paint of the same thickness from each pot to a board, allow to dry and compare the results. That paint has the best covering power which shows the deepest shade, *i.e.*, which has hidden the white board to the greatest extent. In comparing the covering powers of white paints and those of pale shades, the boards should be prepared with drop black ground in turpentine instead of white lead in turpentine. Then the white paint which shows the best colour has most covering power.

54. **Miscibility.**—All colours may not be mixed together indiscriminately in producing tints. Certain colours act on one another by reason of their chemical nature, so that if they were mixed a different result (generally unpleasant) would be produced to that which might be expected. This action may not take place immediately the mixture is made, but may only show after some time. Various lists

of such incompatible colours have been given, which it does lie within the scope of this book to repeat or criticise. To ascertain whether two colours act on one another, make a mixture with oil in weighed proportions, and see if the tint is somewhat like what might be expected; if not, some chemical action has probably taken place and the two colours should not be used in conjunction. If no chemical action appears to have occurred, keep the mixture for (say) one month, then make a fresh mixture in exactly the same proportions, if the two mixtures show precisely the same shade then the colours may safely be mixed. If, however, the mixture which has been kept shows in any way a deterioration of shade, it is certain that some action has taken place, which would probably be more rapid, and certainly as easily perceived, on a painted surface. In a similar manner the effect (if any) produced on colours by other substances which are used in paint (driers, varnish, etc.) may be estimated.

55. Permanence.—Except under special conditions, the sole cause of the fading of colours is found in the action of light. Under

ordinary circumstances, it is therefore only necessary to ascertain the amount of fading resulting from exposure to light. It is not easy to express this fading in any quantitative manner, so that some colour of known behaviour will generally be exposed for comparison. Two conditions must be observed: the two colours must be applied in the same medium and in precisely the same manner, they must be exposed to the action of light at the same spot during the same period of time. Therefore :—

Mix a paint from each of the colours (in oil, varnish or size, as required) and paint two small boards (suitably primed) with each. Expose one board of each kind to the action of light, side by side. Keep the other two boards wrapped in thick paper in a dark cupboard. Compare the shades of the exposed and unexposed boards after seven days, fourteen days, one month, three months, six months, one year. Broadly speaking, it may be said that a colour which has faded perceptibly after seven days will have faded very badly after one month, and that colours which show no sign of fading after six months are

practically permanent. The amount of direct sunlight which falls on the exposed paints makes a great difference in the rate at which they fade, thus at different seasons of the year in the same place, and at the same season in different places, the rate of fading may vary greatly. It follows that a colour, which may be perfectly suitable for use in the shady interior of a room, may be quite unfitted for use in the open air.

56.—We have now to consider the special conditions, other than the action of light, which cause the fading or discolouration of colours. These are chiefly (*a*) the action of the caustic lime in new plaster and cement ; (*b*) the action of water ; (*c*) the action of heat ; (*d*) the action of sulphuretted hydrogen, acids, acid fumes, ammonia and other chemical influences.

(*a*) The action of caustic lime. Plaster and cement, when new, contain caustic lime, which slowly takes up carbonic acid from the air, and thus becomes neutralised. Until this neutralisation has taken place, any colour sensitive to the action of lime, applied in the form of paint or distemper, or on a wall-paper, is certain to be more or less discoloured. Those colours

which are suitable for use in positions where they are exposed to the action of lime (*i.e.*, generally in distempers) are termed "lime colours" or "distemper colours". In order to ascertain whether any given colour is suitable for a "lime colour" it is sufficient to subject it to the action of any strong alkali, and note whether the shade is materially altered.

A rough and ready test is as follows : Place a little of the dry colour in each of two test tubes, add to one water, to the other dilute caustic soda (5 per cent. strength), shake well and allow to stand for some minutes, then compare the tubes to see whether the caustic soda has caused any change in the colour. If there is any change, the pigment is not a "lime colour".

A more rational method is : Slake a small lump of quicklime by adding to it water, a little at a time, in such quantity that the lump falls to a dry powder of slaked lime. Mix 20 parts of the colour and 5 parts of the slaked lime (previously put through a wire sieve if not quite fine) with sufficient thin size, and spread out on white paper.

Allow to dry, and examine the shade. The lime should be absolutely without action if the colour is a "lime colour".

There are certain media occasionally used for water paints, which are themselves strongly alkaline. Colours used for tinting these paints must resist the action of caustic soda ; the test is applied as above.

(b) The action of water. Colours which are to be exposed in the form of paint to the action of rain should not be appreciably soluble in water. Shake up a portion of the colour with cold water, and pour on a filter ; if the liquid does not run through clear, return it to the filter and endeavour in this way to get a clear liquid. If it is not found possible to obtain a clear filtrate the liquid must be allowed to remain at rest in a test tube until the *suspended* particles (which cause the turbidity) have settled. The clear liquid should not then show any colouration ; if it is slightly coloured, it is a matter for discrimination, according to the extent of the colouration, whether the particular substance is suitable for outside use. It might happen that this first quantity of water had withdrawn all the

soluble colour, in which case the pigment would be suitable (in this respect) for outside use. Therefore, remove the colour from the filter paper, again shake with water, and see whether the *clear* liquid is coloured.

It must not be forgotten that the oil or varnish, in which the colour is to be used, will protect it to some extent from the solvent action of the rain.

(c) The action of heat. There are limits to the temperatures which any colour can bear without suffering change, and these limits vary to the widest extent. If a colour is to be used in a situation in which it will be exposed to a temperature higher than that of boiling water, it is necessary to ascertain by experiment whether it is capable of resisting the action of the heat. This can only be done by exposing a small sample of the colour to the temperature which is in question. If an ordinary laboratory drying oven is possessed, the matter is simple. In lack of this apparatus, the sample of colour must be placed in any hot situation available, with the bulb of a thermometer immersed in the colour, and the position of the colour and thermometer changed

until the proper temperature is obtained. (The thermometer must, of course, be observed without removing it from the hot place.)

(*d*) The action of sulphuretted hydrogen, acids, acid fumes, ammonia, etc. It is occasionally required to use colours which are capable of resisting the action of these and other gases and liquids. To take the gases—sulphuretted hydrogen, acid fumes, ammonia—first, the following method may be used :—

Take an ordinary plate, place in the middle a small beaker, and on the top of the beaker a watch glass containing the colour to be tested, then pour on the plate a little substance which produces the particular gas required. Cover the whole with a large beaker or jar upside down and leave for a day or two. Then carefully remove the covering beaker or jar and compare the colour with the original substance. In order to produce around the colour an atmosphere of sulphuretted hydrogen, pour on the plate a little dilute sulphuric acid and add a few fragments of iron sulphide or a little sulphide of zinc (lithopone). Air containing acid fumes is obtained by pouring strong hydrochloric acid on the plate, air con-

taining ammonia by means of strong ammonia solution.

To test the action of liquids shake one portion of the colour with the particular liquid in a test tube and another portion with water, and see whether there is any change in the first tube. It should be stated that a chemical change might occur here and readily escape detection.

57. Influence on the Drying of Oils and Varnishes.—It is well known that certain colours accelerate the drying of the oil or varnish with which they are mixed to form paint, whilst others retard the drying or even quite prevent it. When it is required to ascertain the action of any given colour on the drying of a paint, of which it is to form a constituent, a portion of the dry colour (in fine powder) is mixed on the slab with a mixture of (say) 4 parts of genuine boiled oil and 1 part of turpentine in the proper proportions to give a paint of an ordinary "liquid paint" consistency. This paint is then spread out on a slip of glass or tin, whilst, at the same time, a paint prepared from the same oil and turpentine (or the same varnish, if that is used)

and an indifferent pigment such as barytes or Paris white is spread out similarly and the two paints put to dry in the same place. The paint may be accounted dry when it does not stick to a finger placed lightly on it.

By working in the same manner and using carefully weighed and measured quantities of the colour and oil, etc., it is easy to find how much driers or terebine it may be necessary to add in order to compensate for the retarding influence of the colour on the drying of the paint. In any observations of drying power, whether of oils, paints or varnishes, the following precautions are absolutely necessary if reliable results are desired :—

1. The layers of the paint, oil or varnish must be of the same thickness.

2. They must be spread out at the same time as the standard substance, which must always be used for comparison.

3. Results obtained at different times cannot be compared.

4. The layers of paint, etc., must be left to dry in the same place, exposed to the same amount of light (*not* direct sunlight) and at the same temperature. They must not be

shut up in a box or small cupboard, as might be done with an idea of excluding dust, but must be in some place to which air is freely admitted.

58. Influence on the Durability of the Paint.

—The resistance which paints offer to the action of the atmosphere varies greatly according to the nature of the pigments in the paint, when the same oil is used. There are certain more or less generally accepted opinions as to the proper paints to use in various situations —on wood, iron-work, etc. In order to test the value of these opinions or the suitability of paints composed of other pigments, large patches (on a sheet of iron or large board as required) should be painted with the paints to be compared, and then placed in such a position that all may be exposed to a similar action of the weather. These patches may then be examined after the lapse of, say, 6, 12, 18 and 24 months.

STIFF PAINTS.

59.—The substances which will be considered under this heading are composed of dry colours ground to a stiff paste with oil, turpentine or

varnish. The methods of examination are, in general, very similar to, if not identical with, the methods given for dry colours in the preceding section.

60. Shade.—The paint is already ground, so that it is only necessary to mix a small quantity on a white tile with refined linseed oil to the proper consistency and to compare it with the standard sample similarly treated (see par. 51).

61. Staining Power.—The staining powers of paints are compared by mixing weighed quantities with white lead paint. The difficulty in this case arises in the weighings, but the operation becomes quite easy and accurate if the paints are weighed out on parchment paper and mixed on the same paper. Pieces of parchment paper about 3 in. square may be used.

Put a square of parchment paper on each pan of the balance, then adjust the weight of the piece on the left-hand pan by tearing off or adding scraps until the two pieces are of equal weight. Then weigh on the right-hand piece 0.2 gram of the paint and 1 gram of white lead paint, taking great care in the

weighings. Now add one or two drops of oil by means of the dropping tube, and mix the two paints together on the parchment paper. Repeat this process with the standard sample and then transfer the two mixtures to a white tile to compare the shades (*cf.* pars. 51, 52).

The reducing powers (and hence the qualities) of white paints may be compared in exactly the same manner, by mixing 1 gram of the paint with 0.2 gram of a common black or blue paint (see par. 32).

It is necessary to make certain observations in regard to the accuracy and reliability of this method of comparing the staining or reducing powers of paints. In the first place care must be taken that the paint which is being examined, and the white or black paint which is mixed with it, do not contain any excess of oil, such as sometimes separates when paints are kept. The white paint used for determining the staining power and the black paint for determining the reducing power should therefore be ground stiff. In the second place, what we determine by means of this test is really the staining or reducing power of the pigment in the paint, therefore

we cannot compare together two paints of the same kind which do not contain practically the same quantity of oil. Reliable results are not obtained if one paint is stiff and the other thin; if the dry materials used to make the two paints were exactly the same, the thin paint would still appear to have less staining power. Thus, if two paints to be compared differ in consistency, it is advisable to add a little oil to the stiffer one before weighing out the portion required in estimating the staining power. A better method would probably be to extract the oil entirely from each paint and then work with the dry materials. The extraction of the oil is, however, not always possible, and would require too much time. In the case of colours ground in turpentine it is advisable to allow the turpentine to evaporate from a small portion put in a warm place, then to grind the residue and use it for the test.

62. Covering Power and Miscibility.—The methods have already been given (see pars. 53 and 54).

63. Permanence.—The permanence of paints under the action of light may be tested as

described in par. 55. The medium in which the paint is ground, and the varnish which may be used over it, have some influence on the fading of non-permanent pigments. The paint should therefore be tested exactly as it is intended to use it.

To test paints which are to be exposed to the action of heat, a piece of glass or metal coated with paint must be exposed to the requisite temperature, as in a drying oven or other convenient situation. If an oven cannot be used it may be a matter of some difficulty to ascertain the real temperature to which the paint is exposed, the details of the test must then be arranged according to the conveniences possessed (see par. 56, *c*).

In regard to paints which are to resist the action of acid fumes, ammonia and sulphuretted hydrogen, there is to be considered the action on the medium in addition to that on the pigment. The resistance which a paint offers to these various influences may be tested by spreading it out on a slip of glass, allowing to dry, and then placing in the little apparatus described in par. 56, *d*.

64. Drying Power.—The drying of a stiff

paint is examined by mixing it to a proper consistency with a mixture of (say) 4 parts of boiled oil and 1 part of turpentine. To this mixture there is added either patent driers, to the extent of one-tenth of the weight of the stiff paint, or terebine in quantity according to the strength of the particular preparation used. A standard sample of the same kind of paint is similarly treated, and the drying of the two liquid paints compared on glass or tin. If a standard sample is not used at the same time, then the paint must dry within a time which is regarded as sufficient for the purpose in question; it might under other and possibly more practical conditions require much longer to dry. See par. 57 for the conditions under which drying tests must be performed.

It has been stated that the pigments contained in a paint may very materially retard or hasten its drying. Apart from this influence of the pigments, the good or bad drying of a paint is due to the quality of the oil in which it is ground. A method for ascertaining whether the oil is genuine linseed oil will be given later on. A stiff paint may be ground in an oil

containing quite a large proportion of mineral oil, and yet the mixed paint may dry in a manner which is considered satisfactory enough for many purposes. Broadly speaking, a paint possesses satisfactory drying powers if, when mixed with patent driers (or terebine), genuine boiled oil and American turpentine, it dries in eight to ten hours to such an extent that it does not stick to the finger, and then continues to harden so that, after several days, it is no longer soft.

65. *Durability*.—The manner in which paint resists atmospheric influences is also due in very great measure to the quality of the oil in which it is ground. In the case of paints ground in genuine linseed oil, the nature of the pigment affects the durability (see par. 58). The durability under the influence of the weather can only be tested under practical conditions, with the paint applied to the actual object, wood or iron, which it is required to protect. There are on the market many special paints for ironwork, damp-proofing compositions, etc., which are generally of the nature of enamel paints; these will be more fully treated under *Liquid Paints*, their durability

and suitability under the conditions for which their manufacturers make special claim of excellence can only be tested under practical conditions.

LIQUID AND ENAMEL PAINTS.

66.—Under this description we include all paints which are sold in a condition ready for immediate use without further thinning or the addition of driers. They are known under a variety of names—liquid paints, mixed paints, lustre paints, varnish paints, enamels, anti-damp compositions, anti-corrosive and anti-fouling compositions, etc. The terms liquid paint and mixed paint are generally applied only to paints mixed for use in the ordinary manner, whilst varnish paints and enamels are usually understood to mean paints which contain more or less varnish and dry with a face similar to that of varnished paint. The two classes, however, are found in practice to merge one into the other, so that it is convenient to consider them together.

67. **Drying, Face and Shade.**—These three properties may be examined simultaneously. Stir up the sample thoroughly and spread it

out to dry on a strip of tin or sheet of glass ; at the same time expose a layer of the standard paint with which the sample is to be compared. It is important that the layers of the two paints should be of the same thickness and that this thickness should be that of the coating which would be applied under practical conditions. If there is any difficulty in spreading out equal and uniform layers by means of the finger, a small camel-hair brush ($\frac{1}{2}$ in.) may be used. The brush must be perfectly clean *and dry* before it is dipped in the paints. The progress in drying may be noted from time to time ; a paint which “sets” rapidly and then “dries off” slowly is probably of poor quality as compared with one which “sets” slowly and yet “dries off” within the same period. Generally speaking, a liquid paint or enamel which dries within three or four hours cannot be of good quality, whilst a paint or enamel which takes more than twelve hours may be of good quality, but may also be inconvenient in use.

The use of naphtha and other substitutes for turpentine in liquid paints and enamels may prevent the paint or enamel from “setting”

quite as rapidly as if it were made from genuine turpentine, but if it finally dries and hardens in a satisfactory manner the substitute cannot, on this account, be regarded as harmful. Russian turpentine is always objectionable for reasons which will be considered in dealing with that substance.

When the paint is dry, but not before, its "face" or brilliance may be examined and the shade compared with that of the standard. It is to be noted that paints, which show exactly the same shade when first applied, may be quite different when dry, owing to the floating of lighter constituents to the surface. This is especially the case with pale shades, particularly light blues and greens. The colour of white paints and enamels may alter very considerably during drying and for a few days afterwards.

68. Flash Point.—The flash point of a liquid is the temperature at which it begins to give off an inflammable vapour. If paint of any kind is to be used in the open air it is not a matter of importance that it gives off an inflammable vapour at the temperature to which it is there subjected, because the vapour cannot collect.

When, however, paint is to be used in closed rooms, and especially in enclosed situations, such as ships' holds, where there are unlikely to be draughts of air to carry off the vapours, it is of the highest importance that inflammable vapours should not be evolved from the paint. Fatal accidents have resulted through the use, in closed spaces, of paints which gave off inflammable vapours. The paint, as it dries on the surface where it is applied, gives off its volatile constituents (turpentine, naphtha, etc.) to the air, and finally, if the vapours of these substances are not carried away by currents of air, a highly explosive mixture of vapour and air may be formed. Then if naked lights are used, or a match is struck, the explosion follows. Now such an explosive mixture cannot be produced unless the liquid which is giving off the vapours is at a temperature higher than its flash point; if, therefore, we take care that paint has its flash point at a temperature higher than any temperature at which it is likely to be used, there is no risk of danger.

Turpentine is an inflammable liquid, but it does not, at the ordinary temperature, give off

a vapour which can be lighted. When turpentine is gradually warmed in a closed vessel, which it partly fills, the space above the liquid comes to contain more and more vapour as the temperature of the liquid rises, until, at about 96° F., there is sufficient vapour to produce an inflammable mixture. If a light be then applied, a more or less violent explosion will occur, according to the size of the vessel. When turpentine is warmed in an open vessel, the mixture of air and vapour above the surface of the liquid does not become inflammable until the temperature of the liquid rises to a temperature somewhat higher than that required in a closed vessel—*i.e.*, to about 100° F. It therefore follows that paints, in which turpentine alone is used as the solvent, may be employed with perfect safety at temperatures below 100° F., or to be on the safe side, say below 95° F., which will rarely occur in this country.

It is necessary to adopt some standard for the minimum flash point of paints which are to be used in closed rooms; in the writer's opinion this may reasonably be fixed at the flash point of turpentine—100° F., which would

give an ample margin of safety, and inflict little or no inconvenience on manufacturers. Under stringent precautions paints may indeed be used which give off inflammable vapours at the ordinary temperature, but it is not desirable that such paints should be used without the user being acquainted with their dangerous properties, and without careful supervision over the workmen.

It is a very easy matter to determine the flash point of a paint. Pour a quantity of the paint out into a small dish or any shallow vessel, then pass a lighted match over the surface of the paint without allowing it to touch the paint. If the vapour takes fire, the flash point is below the temperature of the room in which the experiment is done, and the paint most probably contains light naphtha or benzine. It is therefore highly dangerous for indoor use. If the vapour does not fire under these conditions, pour the paint into a small saucepan (the smallest size of enamelled saucepan does very well) to the depth of about $1\frac{1}{2}$ in. Connect a tin mouth blowpipe (or any other tube ending in a small orifice) to the gas-supply by means of rubber tubing,

turn on the gas, light it at the nozzle of the blowpipe and then turn down the gas until the flame is about half an inch long. Put the blowpipe in a position convenient for the right hand. Hold the saucepan containing the paint in a large vessel filled with water at 120° F. and stir the paint with a thermometer. The temperature will gradually rise. At each 5° rise, *i.e.*, when the thermometer indicates 70°, 75°, 80°, 85°, 90°, 95°, 100°, transfer the thermometer to the left hand, which also holds the handle of the saucepan, and bring the small flame on the blowpipe over the surface of the paint but without touching it. Repeat this at each of the temperatures given until the vapour catches fire and a blue flame runs over the surface of the paint. The temperature shown by the thermometer when this occurs is the flash point as found in an open vessel, *i.e.*, the "open" flash point. If the flash point of a paint falls between 80° and 95° F., it may be regarded as generally, but not entirely, safe. For the reasons given above, it is well always to insist on a flash point of 100° F.

69. Durability and Preservative Action.—

The smell of a paint and the face with which it dries, serve to distinguish an ordinary liquid paint, mixed with oil and turpentine, from an enamel paint mixed with varnish. The quality or durability of an enamel may be judged from the elasticity of a dried layer. Let the enamel dry on a piece of tinplate, and, when quite dry, bend the tin ; if the enamel is ground in a good, elastic varnish, the dried layer will show no signs of cracking at the bend. If the enamel cracks badly, then the paint is of inferior quality. The elasticity of the enamel should be proportioned according to its use ; if it is to be handled, it must dry very hard, which may necessitate some sacrifice of elasticity.

The durability and preservative action of enamels depend on the nature of the pigment and varnish they contain, and can only be tested under practical conditions. Anti-corrosive paints and enamels for iron must be tested on iron and, as far as possible, exposed to the influences, the action of which they are intended to resist. Anti-fouling compositions for ships' bottoms can only be tested by making comparative trials, with a composition of

known behaviour, of different patches on the same ship.

70. **Stoving Enamels** must be tested by applying a coat to a piece of tinplate, stoving at the proper temperature and then examining the dried layer as described above. It is in some respects an advantage that a stoving enamel should not dry at the ordinary temperature, or only dry very slowly; it has then more opportunity of flowing during the baking than if it began to dry before it entered the oven.

OIL VARNISHES.

71. Oil varnishes are solutions of a resin and linseed oil (both more or less altered by the action of heat) in turpentine or other similar solvent.

72. **Drying, Colour and Brilliance.**—Take a number of smooth pieces of board, about 4 by 9 in., and prepare all in the same manner with a priming coat, then with white lead or zinc white in turpentine, bound with a little pale gold size, sandpapering each coat, so that there is finally a series of boards all equally smooth and white. Give each board a fair

coat of one of the varnishes to be tested, taking care to use a brush of the same size for each, and that the brush is quite clean and dry. Put aside to dry in some situation protected from dust, but not in a closed cupboard. Comparative freedom from dust in a dusty place may be obtained by supporting at the corners a large square board, or a sheet of iron or tin, at a height of some six inches above a table, and then placing the varnished boards towards the centre of this protected space, in which the air has free movement. Examine the boards from time to time to see how the drying progresses. Also see the conditions under which drying tests must be performed (par. 57). The time during which a varnish is required to dry depends on the purpose for which it is used : a good elastic varnish cannot be expected to dry in less than about eight hours, whilst a very pale elastic varnish may take an hour or two longer, and both will take much longer to become quite hard. A varnish which is to be handled may take a somewhat shorter time, but it must finally dry very hard. So long as a varnish dries and hardens within the requisite time, it is probably a better var-

nish the longer the time at the beginning of drying before it sets, and this period must always be long enough for the varnish to flow properly. When the varnishes are dry compare the colour and brilliance (or "face") with the standard sample. These comparisons should also be made after the lapse of three or four days; varnish which is very bright when first dry, may lose its face by "blooming" after a day or two. It should be remembered that the thicker a varnish the brighter the coat it gives. In the case of pale varnishes, the varnish which is palest when seen in bulk does not of necessity give the palest coating, and the coating which is palest when just dry is not always the palest after the lapse of a few days.

The elasticity of a varnish is judged by noting the extent to which it "gives" to the finger nail when it is quite dry. The varnish may also be allowed to dry and harden on a piece of tin, and the behaviour noted when the tin is bent.

Flatting or polishing varnishes must dry sufficiently hard for the coat to be rubbed down within a day or two. The behaviour

when flatted may be judged by allowing the varnish to dry on a piece of tin plate about 8 in. square, and then rubbing with a wet leather pad and flour pumice. The varnish must wear down evenly without rolling up or showing deep scratches through to the tin.

73. **Durability.**—The durability of a varnish when exposed to the action of the weather depends largely on its elasticity, which may be judged from the drying and the other properties mentioned in the last paragraph. The durability depends, however, to a great extent on the particular resin ("gum") from which the varnish was made, and there is unfortunately at present no method of ascertaining this in most cases, consequently the durability can only be ascertained by varnishing a suitably primed board and exposing it to the weather.

The durability when exposed to the continued action of water may be very different to the durability under exposure to ordinary weather. In this case a test under the exact conditions is requisite.

74. **Consistency.**—The user of varnish re-

quires it to be sufficiently thick to give a proper layer, but not so thick that it cannot be worked out with the brush. The thickness or consistency of two varnishes may be roughly compared by dropping two drops of each on a piece of tin or glass and spreading out each with the finger. In order to *measure* the consistency of a varnish two properties may be utilised—the specific gravity and the viscosity. The specific gravity of a liquid is a number which expresses the proportion of the weight of a given volume of the liquid to the weight of the same volume of water; thus the weight of a gallon of water is 10 lb., the weight of a gallon of turpentine is 8.66 lb., therefore the specific gravity of turpentine is $\frac{8.66}{10} = .866$. If the specific gravity of a liquid is multiplied by 10, we obtain the weight of 1 gallon of the liquid in pounds.

The specific gravity of a varnish is *not* an actual measure of the consistency: varnishes made from different materials may have the same specific gravity, but differ greatly in consistency, and *vice versâ*. However, varnishes made from the same materials, and having the same specific gravity, will generally have the

same consistency. Thus, in a limited sense, the specific gravity may be used to measure the consistency. There is another reason why large consumers of varnish should pay attention to the specific gravity of their deliveries : when varnish is packed in bulk it is usual to tare the barrel, weigh it when full, calculate the number of gallons in the barrel from the net weight and the weight of one gallon, and invoice accordingly. It has been a practice to calculate the number of gallons in this manner on the assumption that a gallon of varnish always weighs 9 lb., which is seldom or never the case ; one gallon of an ordinary oil varnish weighs from 9·3 to 9·5 lb. Let us suppose that a 40-gallon barrel of varnish, 1 gallon of which actually weighs 9·4 lb., is invoiced as if it weighed 9 lb. to the gallon. The net weight of the varnish is $40 \times 9\cdot4 = 376$ lb., but the above (false) method of calculation will show that the barrel holds $\frac{376}{9} = 41\cdot8$ gallons, consequently the purchaser will be charged for about $1\frac{3}{4}$ gallon more varnish than he actually receives. It is thus very evident that, when this method of calculating the volume of the varnish is used, it may be a

great economy to spend a little time in ascertaining the specific gravity of each barrel received. By calculating in a similar manner the consumer may check the number of gallons with which he is charged in any package, without the trouble and inconvenience of measuring out the varnish a few gallons at a time.

75. Now as to the method by which the specific gravity of a varnish may be found. The most convenient instrument to use for this purpose is the *hydrometer*, the form of which shown in Fig. 7 consists of a wide glass tube joined at the bottom to a bulb weighted with mercury and at the top to a long narrow glass tube, inside which is a paper scale, the divisions on which give the specific gravity. It would be inconvenient to use a hydrometer suitable for taking the specific gravity of any liquid; for our purpose it is better to use one which gives specific gravities from 1.000 to 0.900. There are required in addition a thermometer and a tall glass jar or cylinder (see Fig. 7), as high as the hydrometer, about $\frac{3}{4}$ in. wider than the wide portion of the hydrometer.



FIG. 7.

Proceed as follows: Put the thermometer into the vessel containing the varnish, allow it to remain there two to three minutes, then note the temperature and pour the varnish into the tall glass jar to within (say) 4 inches of the top. Next put the hydrometer into the varnish, allow it to float in the centre of the jar without sticking to the sides, leave it for a minute or two until it no longer rises or sinks in the varnish and then note the division on the scale which is just on a level with the surface of the varnish. This number is the specific gravity, but it requires correction. The specific gravity of a liquid varies with its temperature, the warmer the liquid the lighter it is, or the lower the specific gravity. The standard temperature to which it is convenient to correct specific gravities is 60° F.—an ordinary room temperature. If the temperature of the varnish, as shown by the thermometer, was higher or lower than 60° F., we must add to, or subtract from, the specific gravity actually found, in order to obtain the specific gravity at 60° F. Multiply the difference between the temperature of the varnish and 60° F. by 0.00035

and add the result to the specific gravity found if the temperature was above 60° F., or subtract from the specific gravity found if the temperature was below 60° F. Example: the hydrometer indicated 0.935, the temperature of the varnish was 50° F., then the actual specific gravity was $0.935 - 10 \times 0.00035 = 0.9315$. This correction for differences in temperature is perhaps not very important in the case of varnish, but the accurate estimation of specific gravities is important in connection with other substances to be considered later, and an accurate estimation necessitates a correction for temperature.

The hydrometer cannot be used to find specific gravities unless the sample of liquid is of fair size, say 3 to 4 oz., neither can it be used for very thick liquids, such as lithographic varnish, nor when great accuracy is required. It is, therefore, desirable to have another method, which can be used with any liquid, and for which a small sample is sufficient. The method by means of the *specific gravity bottle* is rapid and, with care and cleanliness, quite accurate. The specific gravity bottle (Fig. 8) is a small bottle with a ground-

in stopper through which a narrow hole is drilled. The bottle is made to contain, when the stopper is inserted and all excess squeezed out through the hole, exactly a definite weight of water at 60° F. ; it is convenient to use a bottle which contains 10 grams of water at this temperature. Put the specific gravity bottle, which must be perfectly clean and dry, in the balance case, together with a small bottle of the varnish and a thermometer. After about



FIG. 8.

half an hour fill the bottle with varnish, without touching it with the fingers any more than is absolutely necessary, take the bottle in the left hand by means of a cloth, screw in the stopper quite tight, at once wipe the top of the stopper (but do not remove any varnish which may flow out afterwards), then quickly wipe the sides of the stopper and bottle and weigh. The weight of the empty bottle is then to be deducted, the weight of the varnish divided by 10, and the resulting specific gravity corrected for temperature as described in the last paragraph. It may not be superfluous to give directions for cleaning the bottle. After draining out the varnish, pour in a little turpentine,

shake well and repeat two or three times, then drain, wipe out the turpentine with a thin cloth, and dry. Blow the varnish out of the stopper, run turpentine through the hole, and dry. When necessary, the bottle must be cleaned by filling with strong sulphuric acid, allowing to stand some time, pouring out the acid, washing with water and drying. The stopper is similarly cleaned with strong sulphuric acid in a small beaker. Take care not to get the acid on the fingers or clothes.

76. The various forms of apparatus which are used to determine the viscosity of lubricating oils give a measure of the time required for a definite volume of oil to flow out of a small aperture. These instruments are not suitable for estimating the consistency of varnishes—they are difficult to clean and the varnish would generally take too long a time to run out of the small hole. The simple form of apparatus which is next described is cheap, rapid of operation, easy to clean and gives results quite accurate enough for the purpose. A piece of brass tube, about $2\frac{1}{2}$ in. long and $2\frac{1}{2}$ in. wide (outside measurements) is closed at one end by a concave bottom, in the

middle of which is a piece of narrow brass tube, about $\frac{1}{4}$ in. long and $\frac{3}{16}$ in. bore. This apparatus, when in use, may be held by an ordinary large laboratory clamp attached to a retort stand; if these are not available some simple and rigid support must be devised. A narrow strip of brass about $\frac{1}{2}$ in. wide can be placed across the open top of the brass tube; this strip has soldered on it in the middle a steel spike about $\frac{1}{4}$ in. long. The following is the process: The brass tube is supported so that the top is just horizontal, the brass strip is laid across with the spike downwards, then the varnish is slowly poured in, whilst the narrow tube is closed by a finger, until the varnish just touches the spike. Then, by means of the seconds hand of a watch or a stop-watch (which can be bought for about six shillings), the time is observed which the varnish requires to flow out of the apparatus; the end of the flow is taken to occur when the varnish just ceases to run in a continuous stream. It is allowed to run over the bulb of a thermometer in some vessel beneath, and its temperature thus taken. If this apparatus is to be used for comparing or adjusting the con-

sistency of varnishes, a sample of varnish which is considered to be of the proper consistency is taken as standard, and the times determined which this varnish requires to run out at different temperatures. Thus we get the number of seconds which the standard varnish requires at the standard temperature (say 60° F.), and the correction which must be applied to the results obtained with any similar varnish at other temperatures. The corrections for temperature to be applied to thick and thin varnishes vary considerably.

77. Flash Point.—It is seldom necessary to take the flash point of a varnish, but if the smell indicates the presence of a substitute for turpentine it may be advisable. The remarks made and the methods described in par. 68 apply equally here. In regard to the use of those substitutes for turpentine which do not lower the flash point of the varnish, it may be said that if the varnish dries and (especially) hardens in a satisfactory manner, there can be no objection to their use except on the grounds of smell.

78. Mixing Varnishes are used for mixing with stiff paints in place of, or together with, oil and turpentine. In addition to being ex-

amined for drying, face and colour, they must therefore be tested to see whether they "feed" or stiffen when mixed with the paint. As a rule it is sufficient to mix 8 oz. of white lead paint with 2 oz. of varnish and leave the mixture for twenty-four hours; if it is then no stiffer than when first made the varnish may be used with confidence. If the varnish is to be used in zinc paints, it must be tested with genuine zinc oxide paint in the same manner.

79. **Stoving Varnishes** must be tested for colour, face and drying by stoving a piece of tinplate, coated with the varnishes, at the temperature at which they are to be used. A varnish which may be satisfactory when stoved at 150° F. may be quite unsatisfactory at 250° F., and *vice versa*.

80. **Oil Lacquers** are tested on tin for colour, drying and face. The consistency may also be important.

81. **Paper Varnish** is tested on well-sized white paper for colour, drying and face.

SPIRIT VARNISHES.

82. **French Polish** should be tested by polishing in the ordinary manner a piece of board,

and then examining it for colour, hardness and elasticity. The method for determining the consistency of French polish, or the amount of shellac it contains, will be given subsequently (par. 138).

83. **Knotting Varnish** should be made from pure shellac; the method of examination will also be given in a future chapter.

84. **White Hard and Brown Hard Spirit Varnishes** may be examined for colour in a small bottle, spread out on tin to dry and the dried coating examined for face and elasticity.

85. **Spirit Stains and Lacquers** are applied to a piece of tin, allowed to dry and then examined for colour, face and elasticity. "Cold lacquers," *i.e.*, lacquers which can be used without stoving or warming the metal to which they are applied, should dry with a perfectly bright face without the aid of heat. Other lacquers, which are to be stoved or applied to warm metal, may require gentle warming in order to obtain a perfectly bright coating.

DRIERS.

86. **Patent Driers** are used primarily in order to impart to a mixed paint the drying

agents required by the raw oil in the paint. It is necessary that they should not materially alter the shade of the paint with which they are mixed. Thus we have the following method of testing: mix 5 oz. of white lead paint with $\frac{1}{2}$ oz. of the patent drier (weighed carefully), and 1 oz. of raw linseed oil, and spread out on glass to dry. Treat a standard quality of patent drier in the same manner. Compare the drying of the two paints and also, when dry, the colour. The best patent drier is that which imparts the greatest drying power with the least discolouration of the white lead. Since the white lead assists the drying power of the patent driers, it is advisable to mix paints from (say) a stiff Venetian red paint (or other paint free from lead) and the samples of driers to be tested, and compare the drying in this case also.

Patent driers are sometimes used alone in place of stiff paint; it is therefore advisable to test the drying of the stiff drier mixed to a proper consistency with boiled oil alone, and to examine the colour of the dry coating.

These practical tests for the examination of patent driers may be considered sufficient

without any chemical examination. If the absence of mineral oil is desirable, the oil must be extracted and examined as described in par. 99.

87. **Dry Driers** are powders which can be used in place of the paint-like "patent" driers. Mix 5 oz. of white lead paint with 1 oz. of boiled oil and then stir in $\frac{1}{4}$ oz. of the dry drier, put on glass to dry, and compare the drying and colour with those of a paint made up in the same manner from a standard sample.

88. **Terebine** is to be tested for its drying action and examined for colour. Mix 1 dram of terebine with 9 drams of raw linseed oil (par. 91, end), make a similar mixture with a standard terebine and put the two on glass to dry. The drying of terebine by itself is generally also tested, though there is no logical reason for this course. The manner in which terebine dries by itself is absolutely no criterion of the drying power it can impart to linseed oil; indeed it is possible to make a varnish which dries hard in ten minutes, but which does not assist linseed oil to dry in the slightest degree.

PUTTY.

89. There is no practical test by which the quality of a sample of putty can be readily gauged. It is therefore better to consider putty as a mixture of whiting and linseed oil, and to regard all other substances as adulterants. The methods for ascertaining the presence of adulterants will be given in a future chapter (see pars. 98 and 104). Putty is found occasionally to contain barytes, and frequently to contain mineral oil, the presence of which latter in any quantity is probably deleterious. Putty should always be examined for mineral oil by the method given in par. 99 for the extraction of oil from paints.

LINSEED OIL.

90. Linseed oil is used in the three forms of raw oil, refined oil and boiled oil. These all require certain differences in the method of examination, which are indicated below. The specific gravity is always to be determined, and in the case of raw and refined oil a careful determination is requisite, consequently the specific gravity bottle should be used.

The clean bottle is filled with the oil and allowed to stand in the balance case alongside the thermometer for about twenty minutes. The stopper is then inserted, and the weighing finished with the precautions given in par. 75. When linseed oil is bought at a price per gallon, it is always desirable to make sure that the proper quantity is delivered. The practice of calculating the number of gallons on the (false) assumption that a gallon of oil weighs 9 lb. is materially to the loss of the buyer (see par. 74). A 5-gallon drum of raw or refined linseed oil should contain $46\frac{1}{2}$ lb., not 45 lb.; a 5-gallon drum of dark boiled oil should not contain less than 47 lb.

91. **Raw Linseed Oil** is examined by smell and taste in comparison with a sample known to be genuine, and for colour in a small bottle; it should be perfectly clear. The presence of rosin oil is discovered both by the characteristic odour and biting taste; it is, however, more certainly found by another method given in a future chapter. The specific gravity of raw linseed affords one of the best tests of purity. The specific gravity of genuine raw linseed oil is never less than 0.930 at 60° F.;

a specific gravity of 0.929 would indicate probable adulteration. The maximum limit of the specific gravity of ordinary linseed oil is about .933. Baltic linseed oil ranges in specific gravity from 0.933 to 0.935; as a rule, the higher the specific gravity, the better the oil. The usual adulterant of raw linseed oil is mineral oil, which lowers the specific gravity, whilst rosin oil increases the specific gravity; the presence of neither of these oils should be regarded as proved unless the saponification test (par. 139) confirms the indication of an abnormal specific gravity. The presence of an ordinary mineral oil is indicated by the characteristic greenish "bloom" or fluorescence, which is best seen on looking along the bottle containing the oil, which is held against some dark object in front of a window. The presence of "bloomless" mineral oils cannot of course be detected in this manner, and samples of apparently genuine linseed oil have been known to be fluorescent.

Assuming that the specific gravity of genuine linseed oil is 0.930 and that of the mineral oil used for adulteration is 0.885, the percentage of mineral oil may be calculated as follows:

Subtract the specific gravity of the adulterated oil from 0.930, and 0.885 from the specific gravity of the adulterated oil. These differences give the proportions of mineral and linseed oils. Thus, if an adulterated oil has a specific gravity of 0.925, then $0.930 - 0.925 = 0.005$ and $0.925 - 0.885 = 0.040$; 0.005 is to 0.040 as 5 is to 40, therefore the oil contains $\frac{5 \times 100}{40} = 12.5$ per cent. of mineral oil. This example shows that it is difficult to detect a *small* addition of mineral oil by means of the specific gravity, and that, consequently, the greatest accuracy is required in the determination of the specific gravity.

The drying of raw linseed oil is best tested in the following manner: Keep a large sample of a satisfactory oil as standard. Take a 2 oz. conical glass measure, put into it exactly 1 dram of terebine, and fill up to the 10 dram mark with the standard oil, mix well with a glass rod, put two drops of the mixture on a clean piece of glass or tin, and spread out with the finger. Repeat this process with the oils under examination, put the pieces of glass or tin aside to dry (see par. 57), and note the drying. A fresh mixture of the standard oil

and terebine must be made up every day a test of this nature has to be performed.

92. Refined Linseed Oil is examined for colour, smell, specific gravity and drying, exactly in the same manner as the raw oil. The specific gravity is the same as that of raw linseed oil. Refined linseed oil should be perfectly bright and clear ; if the oil is genuine and dries well, it is better the paler the colour.

93. Boiled Oil is examined for colour in a small bottle ; for smell, which varies according to the method of boiling and the length of time the oil has been made ; for drying, by spreading out two drops of oil on a piece of glass or tin and leaving to dry alongside a similar layer of a standard oil. The "body" of the oil will be noted in this last test ; the oil should dry within a certain time, which depends on its colour, and should then become hard ; if it remains soft and sticky it is certainly of bad quality. The presence of rosin oil may be detected by the smell and that of mineral oil perhaps by the "bloom" (see par. 91).

The specific gravity of boiled oil affords

some indication of its genuineness ; the specific gravity of very pale boiled oil is about 0.935, though, if made by a particular process, the oil may be very thick and have a specific gravity of about 0.960. The specific gravity of dark boiled oil ranges from 0.940 to 0.950 ; lower or higher values for pale or dark oils would generally indicate the presence of mineral oil or rosin oil.

Certain adulterated boiled oils, or substitutes for boiled oil, are made with mineral oil of comparatively low flash point. Thus the flash point *may* serve to detect the presence of mineral oil, but probably would not detect the presence of small quantities of mineral oils of high flash point. Put a small beaker (the tall shape, about 3 in. high, is convenient) on a piece of wire gauze on a tripod and half fill it with the oil to be tested. Either fix a thermometer by means of a clamp so that the bulb is at the middle of the layer of oil, or use the thermometer for stirring the oil. Begin to heat with a Bunsen burner, and when vapours are noticed over the surface of the oil at once remove the burner and pass a small flame (see par. 68) over the surface of the oil. In case

a flash should follow, the flash point has been overstepped, and the experiment must be recommenced with a fresh quantity of oil. When the appearance of vapours indicates that the flash point is near, continue heating with a small flame, so that the thermometer rises slowly (say 5° per minute), and pass the tiny flame over the surface of the oil at every 2° . The temperature at which the flash occurs is noted. A flash point below 420° F. indicates adulterated oil.

Boiled oil, if adulterated with certain substances, "feeds" or stiffens when mixed with white lead. Mix 8 oz. of white lead paint with $1\frac{1}{2}$ oz. of the boiled oil and $\frac{1}{4}$ oz. of turpentine; this mixture should not turn solid or thicken on keeping. If the oil passes this severe test, it may be used without fear of "feeding".

In regard to the use of adulterated or reduced boiled oil, if the buyer is aware that he is receiving a reduced quality, and pays a fair price for it, no objection can be made to the transaction, and if also the oil is satisfactory for the purpose for which it is intended, the buyer is justified.

TURPENTINE.

94. **American Spirits of Turpentine**, commonly known simply as turpentine, should be nearly water-white in colour and of the well-known pleasant odour. Turpentine is used simply to thin paints and varnishes, from which it evaporates when the paint or varnish is laid on ; it has no drying action.

Turpentine should leave a very slight residue when it dries (evaporates). Put a large beaker half-full of water on wire gauze over a tripod stand, on the top of the beaker place an evaporating basin, and put a small wedge of paper between basin and beaker to leave an exit for the steam. Clean and dry the basin and weigh it, put into it 10 c.c. of the turpentine, now boil the water in the beaker until the turpentine has evaporated as far as it will. Dry the outside of the basin and weigh again. The weight of the residue should not be more than 0.2 gram.

The specific gravity of turpentine is 0.866. If the specific gravity of a sample is found to be as low as 0.864, adulteration is practically certain. The solubility in methylated spirit should then be examined (par. 140).

If a sample of turpentine is found to be adulterated, there arises the question whether the adulterated substance is sufficiently good for practical requirements. Reduced qualities should be examined for the residue left on evaporation (as above), the flash point, and the drying. The flash point of turpentine as found by the test given in par. 68 is about 100° F. No lower flash point should be permitted. The drying (evaporation) of turpentine is best examined as follows: Thicken several ounces of quick-drying goldsize by heating it in a basin placed over a beaker of boiling water (as above), stirring occasionally. When the goldsize is fairly thick, allow it to cool, then make mixtures of 2 drams of the thick goldsize with 1 dram of each of the samples of turpentine to be tested (one of which should be genuine). Put each mixture to dry on glass or tin; a reduced quality of turpentine, or a substitute for turpentine, may be regarded as satisfactory if the thin goldsize, made from it in this manner, dries in the same time as the thick goldsize thinned with genuine turpentine, and if also the flash point is not below 100° F. and the odour is unobjectionable.

95. Russian Turpentine has a very objectionable odour and dries badly; it will be found to leave a more considerable residue than American turpentine when evaporated over boiling water as described above.

WATER STAINS.

96. When dry stains are to be compared, a portion of each sample is well stirred with the same volume of hot water, a little size added, and 2 or 3 drops of the liquid then rubbed out with the finger on a piece of planed board. Liquid stains may be at once applied to wood. Different woods, or even pieces of the same board with a different grain, give different shades. If the stain is to be varnished over, it may be necessary to ascertain whether the stain prevents the varnish from drying.

CHAPTER IV.

THE CHEMICAL EXAMINATION.

97. In the last chapter the practical methods for examining the most important painters' materials were given. We now pass on to the chemical methods, which are used in support of the practical tests, or to decide in cases in which the latter are impossible or too lengthy. The manner in which these various tests are applied—the manipulations—have already been given; whenever there is difficulty in conducting a simple operation some small detail has probably been overlooked; the operator should then refer to the proper paragraph in Chapter I. It cannot be too strongly urged that the ease with which an apparently simple operation is conducted depends on the observance of detail, which can partly be learnt only by practice; the somewhat minute instructions in Chapter I. are intended mainly to assist those who have little experience in the use of chemical appa-

tus. The greatest care must be taken that all apparatus is perfectly clean ; neglect of this precaution will infallibly lead to mistakes.

DRY COLOURS AND PAINTS.

98. Extraction of Oil.—It is frequently necessary to extract the oil from paints (either stiff or liquid) in order to obtain the material in the dry state, in which alone it can be subjected to certain of the tests. For this purpose take about 5 grams of the paint ($\frac{1}{8}$ - $\frac{1}{4}$ oz.), put in a small beaker (the tall shape), add a little ether (sp. gr. 0.720) and stir until all the paint is thoroughly mixed up, then fill up the beaker with ether nearly to the top, stir, cover, and set aside to settle. When the colour has settled, pour off the clear ether, add more ether, stir up, again allow to settle, and pour off the ether. Then scrape out the paste at the bottom of the beaker and put it on a pad of three or four thicknesses of blotting paper or filter paper, the lower layers of which are renewed as they become wet with the ether. In a short time the material is practically dry, it is then ground and put in a warm place for a few minutes, when it is

ready for use. In the case of certain paints the settling of the ether mixture may take a long time ; it may be permissible, according to the nature of the paint and the purpose for which the dry material is required, to pour off the turbid liquid and use only the heavier part, which has already settled. Ether is extremely inflammable ; it must never be used within (say) two feet of a flame or fire.

99. The oil in a paint is extracted for examination in a similar manner ; it is, however, better to mix the paint with a smaller quantity of ether. Take 10 grams of the stiff paint, mix with 10 c.c. of ether thoroughly, then add about 20 c.c. more ether (according to the nature of the paint), and allow to settle. Pour off the top of the clear ether solution into an evaporating basin, taking care that none of the colour accompanies the ether. The ether is then to be evaporated, which may be done by floating the basin in a large vessel of warm water at about 120° F. When the liquid no longer boils the basin is placed on the top of a large beaker standing on a tripod, the water in the beaker is boiled, and the evaporation of the ether is thus completed. Assist the final

removal of the ether by allowing the oil to flow over the surface of the basin, so that a large surface is exposed, and by blowing the oil about. It is necessary to drive off all the ether. The oil is now obtained, and may be examined. The quantity is too small for either of the methods of determining specific gravities previously given ; the following method, however, gives an approximate result with one or two drops of oil. Make a mixture of equal parts of strong ammonia and water, take the specific gravity by means of the hydrometer, and add water or ammonia, whichever is required, in small quantities at a time, until the specific gravity of the mixture is exactly 0·927. Then take a drop of the oil extracted from the paint out of the basin by means of a palette knife or glass rod and drop it into the dilute ammonia (the drop must not take a bubble of air with it below the liquid). If the drop of oil rises to the surface of the ammonia, its specific gravity is lower than that of the ammonia and consequently it is not genuine linseed oil. If the oil sinks to the bottom, it may be assumed to be genuine, if rosin oil cannot be detected by the smell. The actual specific gravity of

the oil is found by adding ammonia or water, according as the drop floats or falls, until it remains suspended in the liquid without rising or falling. If the liquid has been stirred, it is necessary to wait until the motion has ceased, in order to ascertain whether the drops will rise or sink. The specific gravity of the ammonia is then taken by means of the hydrometer. Methylated spirit may be used in place of ammonia; the ordinary retailer's spirit, however, which becomes turbid when mixed with water, is not very suitable. The methylated spirit used in varnish making is quite satisfactory. The oil is further to be examined by the saponification test (par. 139). These methods cannot be applied to liquid paints which contain turpentine or other similar solvent.

100. Extraction of Varnish.—From enamel paints and similar liquid paints containing varnish, the varnish is best extracted in a slightly different manner. Mix the paint with an equal volume of rectified benzol, and allow to subside, pour off the clear liquid carefully into an evaporating basin, which place on the top of a beaker of water arranged as above.

Boil the water and thus evaporate off the benzol, blowing the vapour out of the dish from time to time, until a drop of the varnish taken out on a glass rod and cooled on a piece of tin or glass is found to be of a proper varnish consistency. It may then be examined in the same manner as any other varnish. The settled paint, from which the varnish has been partially extracted, is now mixed with three times its volume of benzol, again allowed to settle, the clear liquid poured off and thrown away. This treatment with three volumes of benzol is repeated and then the extraction is finished by means of ether as described before. The dry material is thus obtained free from varnish and in a fit condition to be subjected to the various tests.

WHITE PIGMENTS AND PAINTS.

101. **White Lead**, whether dry or paint, is examined for fineness of grinding, colour and reducing power. White lead paint may be distinguished from zinc white paint by the fact that it is at once blackened when touched with a drop of ammonium sulphide. Dry white lead is also blackened by the same

substance ; it dissolves in dilute acetic acid with a violent effervescence of gas and the solution then gives a lemon-yellow precipitate with bichromate of potash and a golden precipitate with potassium iodide. Practically the only adulterants used for white lead are barytes (barium sulphate) and lead sulphate. If white lead paint is to be examined, take a small quantity on the end of a glass rod, put the rod carefully down a test-tube and transfer the paint to the walls of the tube about half an inch from the bottom. Add strong nitric acid sufficient to cover the paint and warm carefully over a small flame, taking care not to heat the portion of the tube where the paint is attached. Bubbles of gas, which produce red fumes, are soon given off; when this occurs take the tube away from the flame and put in the stand until the reaction is over. Then add water to the extent of two to three times the volume of the acid, and heat whilst shaking the tube. When the liquid has boiled, allow it to stand for a few minutes. If the paint is pure white lead, no sediment will be seen at the bottom. If there is a sediment, pour off the liquid, add water, boil, let settle and pour

off the liquid as completely as possible, finally allowing the white powder at the bottom to drain towards the mouth of the tube. Take a platinum wire (par. 20), dip it in strong hydrochloric acid and hold it in the flame of the Bunsen burner, repeat the dipping in acid and heating in the flame until the wire gives no colouration to the flame. Then dip the wire in hydrochloric acid and touch the sediment in the test-tube with it, in order to get some of the sediment on the wire, then heat in the flame; a green colouration denotes the presence of barytes. This flame test for barytes may also be performed on the original paint, a very small portion of which is heated on the platinum wire, the wire repeatedly dipped in hydrochloric acid and heated in the flame until the blue flame due to the lead disappears. If barytes is present, a green flame is then seen. Either of these tests is sufficiently delicate to detect the presence of as little as 1 per cent. of barytes (sometimes much less can be found). Now a small quantity, such as 1 per cent., of barytes can easily be accidentally introduced in grinding the paint, as in changing the mill from a reduced quality

to genuine white lead. The presence of such quantities cannot be regarded as evidence of adulteration, whilst, of course, the addition of 3 to 5 per cent. would constitute adulteration. Therefore, if a very small quantity of sediment is obtained after boiling with nitric acid as described above, the paint must not at once be regarded as adulterated; a quantitative analysis must be made by a chemist in order to ascertain the exact quantity of barytes present. No charge of adulteration should be made except on the clearest evidence.

Terra alba (gypsum, calcium sulphate) and Paris white (calcium carbonate) would be shown by flashes of scarlet colouration in applying the flame test to the paint. These substances are very rarely used in white lead paints. Any considerable quantity of lead sulphate would be found as a sediment in the nitric acid test; it would give the purple lead colouration in the flame test.

There has been a decision of a court of law that lead sulphate may be described as white lead; whatever the lawyers may decide, there is, however, no doubt that lead sulphate is a much inferior substance to the basic carbonate

of lead, which alone is really entitled to be described as white lead.

Dry white lead is best tested by boiling with dilute acetic acid, pouring off the liquid and again boiling with acetic acid. There should be no residue, and a perfectly clear solution should result. Any sediment obtained on standing is examined by the flame test (remember to apply this test with great care, see pars. 20, 101), a green colouration indicates barytes, a scarlet colouration terra alba, the purple lead colouration indicates lead sulphate. The flame test is also to be tried on the original sample; the presence of Paris white is shown by scarlet flashes of colouration.

A comparison of the reducing powers (pars. 52, 61) of lower qualities of white lead paints enables the value to be approximately fixed, if paints of known composition or value are used as standards.

102. **White Sugar of Lead** is rarely adulterated. It is examined for colour; it should give a clear solution in water to which a few drops of acetic acid are added. Sugar of lead is recognised by the smell of vinegar (acetic acid) given off when it is boiled with dilute

sulphuric acid, and by the shining golden precipitate given with a solution of potassium iodide.

103. Zinc White.—There are two kinds of zinc white used in white paints—ordinary zinc white or zinc oxide, and lithopone, which is a mixture of zinc sulphide and precipitated barium sulphate in varying proportions. Now barytes is natural barium sulphate, so that the discovery of barium sulphate in a zinc white or paint may imply the presence either of barytes or lithopone.

Zinc oxide dissolves entirely in dilute acetic acid or hydrochloric acid, and the solution in acetic acid gives no precipitate on adding a solution of potassium iodide. Lithopone is quite insoluble in acetic acid; when boiled with dilute hydrochloric acid it partially dissolves, leaving a residue of barium sulphate, which may be examined by the flame test, and evolving the disagreeably smelling gas sulphuretted hydrogen, which has an odour similar to that of rotten eggs. In order to detect this gas, and hence the presence of lithopone, boil with dilute hydrochloric acid and hold a piece of filter paper moistened with lead

acetate solution in the mouth of the test tube. The paper is at once blackened if lithopone is present.

The substances for which we have to look in a dry zinc or zinc paint are lithopone, barytes, terra alba (gypsum) and Paris white. In the case of a paint, transfer a portion to the side of a test tube near the bottom by means of a glass rod, cover with dilute hydrochloric acid and boil. In the case of a dry zinc, simply boil with the dilute acid. Test the gases which escape for sulphuretted hydrogen as described in the last paragraph. If lithopone be detected in this manner, it is useless to test for barytes. If lithopone is not present, boil a portion of the paint with strong nitric acid as described in par. 101, and test any sediment for barytes by the flame test (green). In the case of a dry zinc, if lithopone is absent, any sediment left after boiling with hydrochloric acid is tested on platinum wire in the flame; a green colouration again indicates barytes.

In a dry zinc or zinc paint, terra alba and Paris white are detected by means of the flame test, when crimson flashes are seen.

These substances are not usually present in considerable quantity in zinc paints, and when the paint is already found to contain barytes, their presence is not of much importance.

By these simple tests it is easy to ascertain whether a dry zinc or zinc paint is pure zinc oxide. It is, however, impossible to ascertain the quality of dry zincs and zinc paints containing lithopone in this manner. The comparison of quality is best made by means of comparative tests of reducing power (pars. 52, 61) against samples of known value.

104. Whiting, Paris White.—These substances are examined for fineness by spreading out on paper with a knife; they are also compared for colour with standards. They are further examined in oil for colour and fineness of grinding.

Whiting and Paris white are essentially calcium carbonate (carbonate of lime); they contain, in addition, certain small quantities of sand and other impurities. They dissolve in hydrochloric acid with a rapid evolution of gas (carbonic acid), whilst the sand is left undissolved. In the flame test they give a scarlet colouration.

Putty should consist entirely of whiting ground in genuine linseed oil. Samples are occasionally found to contain barytes, which may be detected by means of the flame test, and by boiling a portion with strong nitric acid, as described for white lead paint, and examining the residue, which will always contain the sand from the whiting.

YELLOW PIGMENTS AND PAINTS.

105. **Litharge.**—This oxide of lead, which is used principally as a drier, is rarely adulterated. It should first be examined for fineness of grinding and for colour. Rub the lumps out of a small portion of the sample by means of a palette knife, boil some dilute acetic acid in a test tube, add the litharge, and boil until all is dissolved. If necessary, allow to settle, pour off the clear liquid, add more acetic acid and boil again. Commercial litharge is never quite pure, it always contains more or less red lead and metallic lead, which do not dissolve in acetic acid under these conditions. The residue finally obtained in the above test should consist only of a little red lead, with, perhaps, some metallic lead.

That sample is best which leaves the least residue.

106. **Chrome Yellows** are essentially chromates of lead. Whilst middle chromes should be practically pure normal lead chromate, orange chromes are basic chromates, and lemon chromes are compounds of lead chromate and sulphate. When chrome yellows (all shades) are boiled with strong hydrochloric acid, the gas chlorine is evolved, a green solution is formed, and, on cooling, needle-shaped crystals of lead chloride are deposited.

The term "pure" chrome ought undoubtedly to be restricted to the pure compounds enumerated above for the different shades. It has, however, come to be customary to describe all chrome yellows as pure which contain nothing but lead compounds; that is to say, red lead, white lead and lead sulphate may be used for reducing the quality of really pure chromes of the different shades, and yet the mixture be described as pure. In consequence, with whatever guarantee of purity a chrome may be bought, or however free it may be from substances other than lead compounds, it is always necessary to subject it to some kind of quan-

titative examination, such as of the staining power. It is hardly possible to judge the quality of a chrome from the shade alone. The staining power of orange chromes is best tested by grinding with white lead as previously described (par. 52). In the case of middle and lemon chromes, it is better to replace the white lead by a Brunswick blue, and judge the staining power from the shade of the green obtained by comparison with standard chromes similarly treated. The stronger or more pure the chrome, the yellower and paler will be the shade of the green it produces. It is convenient to grind 0.5 gram of chrome with 0.2 gram of Brunswick blue.

In order to detect red lead in an orange chrome, powder it and add strong nitric acid; a pure chrome is at once converted to a very bright lemon shade, whilst a chrome containing red lead gives a dirty middle shade. Boil the acid, add water, let settle, pour off the clear liquid, add more acid if there is any residue, boil again, add water, let settle and pour off. A pure chrome dissolves entirely by this treatment, whilst a chrome containing red lead leaves finally a very dark, brownish-red resi-

due. Pure orange chrome is also entirely soluble in boiling caustic soda solution to give a yellow solution ; an orange chrome containing red lead gives a solution which is red, owing to the suspended red lead.

White lead is detected in middle and lemon chromes by the efflorescence of carbonic acid on warming with dilute nitric acid. Warm gently in a test tube, and, if bubbles of gas are seen, lower into the tube carefully a glass rod carrying a drop of lime water at the end. After about a minute withdraw the glass rod ; if carbonic acid was present in the tube (produced from white lead in the chrome), the drop of lime water will be turned distinctly white. The presence of a small quantity of white lead is perhaps permissible in a pure chrome.

A pure lemon or middle chrome dissolves immediately on warming with strong hydrochloric acid, a chrome which contains added lead sulphate is not entirely soluble. Another test is as follows : Boil a small quantity of the powder with caustic soda solution ; a pure chrome dissolves at once, whilst a chrome to which lead sulphate has been added leaves a white sediment.

The other substances which are commonly used for reducing the quality of chrome yellows are barytes, terra alba and artificial barium sulphate. The first and last of these are detected in the original chrome (the dry colour or paint) by means of the flame test; if only small quantities of barytes or artificial barium sulphate are present it is necessary to dip the wire repeatedly in hydrochloric acid, and heat in the flame in order, finally, to obtain the green barytes flame. Instead of testing the original chrome it is better to boil with strong hydrochloric acid until the mixture consists of a green liquid and white sediment, add water, boil again, let settle, pour off the liquid, add water and boil, and repeat this process until all the crystalline lead chloride is removed. If there is then any residue it is tested in the flame for barytes; the absence of a residue indicates the absence of barytes. If the original substance is a chrome paint, the oil must be removed and the dry material prepared for the test as described in par. 98. Terra alba is found by means of the flame test (scarlet) in the original dry chrome.

The lower grades of chromes are tested for

staining power in the same manner as the "pure" chromes, and their quality thus ascertained.

107. Zinc Yellow is a chromate of zinc. It is distinguished from the lead chromes by being soluble in water to give a yellow solution. Zinc yellow is readily soluble in strong hydrochloric acid; on heating the solution turns green, and chlorine gas is evolved. It is to be examined for colour and staining power in the same manner as the lead chromes.

108. Permanent Yellow, Yellow Ultramarine is barium chromate. It is recognised by the following tests: It is insoluble in water, easily soluble in strong hydrochloric acid to give a green solution, and gives a green colouration to the flame. This pigment is rarely used, and it is probably unnecessary to test it for admixtures.

109. Ochres and Yellow Paints.—The presence of an ochre in a dry colour may be recognised by boiling with strong hydrochloric acid, when a yellow solution is obtained (there is always a residue); then dilute largely and add a solution of potassium ferrocyanide (yellow prussiate of potash), a blue precipitate or colour-

ation is produced. In the case of a paint this test is performed on the residue obtained by burning off the oil. For this purpose a small quantity of the paint may be heated on an old palette knife or in a porcelain dish, or on a broken piece of porcelain.

Ochres and yellow paints are principally to be examined for fineness of grinding, shade in oil and staining power. The composition of an ochre is generally of little importance as compared with its practical qualities. It may, however, be occasionally necessary to ascertain whether lead compounds (chromes, etc.) have been used to produce an artificial ochre and whether barytes has been added. The latter may be found by means of the flame test, as described before. The presence of chromes may be proved in the following manner: Boil the powder (in the case of a paint, obtained by extracting the oil, see par. 98) with caustic soda solution. Allow to settle, pour off the clear solution and add to it acetic acid until the liquid is acid (test with litmus paper). If a chrome was present in the ochre it will now be thrown down as a yellow precipitate.

110. **Dutch Pink** is a common yellow lake,

containing large quantities of terra alba, Paris white, etc. It is to be examined for shade and staining power. It may be identified by means of the following tests : Boil with water and filter, boil another portion with methylated spirit and filter, both filtered liquids must be practically colourless ; on boiling with water a characteristic odour is perceived. Boil with dilute hydrochloric acid ; a yellow solution is obtained and perhaps a white residue ; the residue should not be yellow, which would indicate the presence of a chrome or ochre. Boil with caustic soda solution, let settle, pour off the clear brown solution and add hydrochloric acid ; the liquid is almost decolourised.

BLUE PIGMENTS AND PAINTS.

111. **Chinese and Prussian Blue.**—The blue pigments known under these names have a similar chemical composition ; they differ in shade and staining power. Chinese blue is the term applied to the best quality, which has a fine coppery lustre and great staining power and produces clean shades when reduced. Prussian blue has much less lustre, less staining power, and produces reddish slatey shades

when reduced. Steel blue is a Chinese blue which gives a paint with a peculiar steely lustre in place of the ordinary coppery lustre. It may occasionally be necessary to test these blues to see whether any adulterant has been used, but the methods by which they are made produce genuine blues of such different shades and staining powers that the best tests are simply those of shade and staining power, by which the quality of a sample may be judged in comparison with standards. A high lustre is a sign of purity and the production of pure shades.

112. Brunswick Blue, Mineral Blue, etc.—These (and other) terms are applied to the reduced qualities of Chinese and Prussian blue, which are far more largely used for ordinary decorative purposes. There is no object in testing for the material used to reduce the shade; a sufficient test of the quality is given by comparison of shade and staining power with standard samples. It may however be necessary to prove that a given sample is a reduced Prussian blue and not a copper blue or an ultramarine. Boil the dry powder or a small portion of the paint

with caustic soda solution ; the blue is at once turned to brown. Boil the dry powder or a small portion of the paint with dilute hydrochloric acid ; it should remain practically unchanged and give a bluish solution. If the colour is destroyed and sulphuretted hydrogen given off (test by smell and paper dipped in lead acetate held in the mouth of the tube), the blue is ultramarine. If the colour readily dissolves to give a yellowish-green solution, the blue is a copper blue.

113. Copper Blues, Blue Verditer.—The blue pigments containing copper are identified by giving a deep blue solution when warmed with ammonia, and a yellowish-green solution in hydrochloric acid. It is generally sufficient to examine for shade alone. Certain copper blues contain arsenic, which renders them unfit for most purposes—probably few would knowingly use a colour containing arsenic for distemper work, for example. In order to detect the presence of arsenic, boil with caustic soda solution. The liquid will turn yellow and then red, and finally deposit a peculiar reddish precipitate if arsenic is present.

114. Ultramarine, Lime Blue.—Ultramarine

blue is the product of certain special works ; the ordinary paint and colour maker generally only acts as a dealer* and probably rarely adulterates the colour. It is not necessary to test ultramarine for impurities, but simply to examine its shade and staining power. It may, however, be requisite to ascertain whether a blue shade in a dry colour or paint has been obtained by means of ultramarine or Chinese blue. The following simple tests are sufficient to identify ultramarine and to prove its presence as a shading colour : Boil the dry colour or paint with dilute hydrochloric acid, and hold a piece of filter paper moistened with lead acetate solution in the mouth of the test tube. If ultramarine is present, the blue is rapidly destroyed and the lead acetate paper is blackened. The same blackening of the paper, due to sulphuretted hydrogen, would be produced by lithopone. Boil the dry colour or paint with caustic soda solution ; if the blue colour is due to ultramarine, it is not destroyed.

115. Blue Lakes.—Certain blue lakes made from coal-tar dyes are sold under the name of Night Blue, Peacock Blue, etc. The

presence of these lakes in a dry colour is proved by boiling with water and methylated spirit (separately), and filtering. Both the water and the spirit are coloured deep blue. Brunswick blues would not give more than a faint green solution.

GREEN PIGMENTS AND PAINTS.

116. There are many different kinds of green pigments in common use, and, since the names are frequently carelessly applied, it is generally desirable to make some examination in order to ascertain whether a sample is what it is stated to be.

117. **Chrome Greens.**—The greens obtained from mixtures of chrome yellow and Prussian or Chinese blue are known under a great variety of names—chrome green, Brunswick green, oil green, coach green, bronze green, etc. The quality varies from a mixture of pure chrome and pure Chinese blue down to a mixture containing so much reducing material that it is a mere tint. The shade and staining power are of course to be examined.

Chrome greens are detected by the following tests: Warm for a minute or two with

caustic soda solution ; a yellow solution is produced and the green is turned brown or reddish-yellow. Shake with dilute hydrochloric acid, the colour is not destroyed, but the shade becomes bluer ; on boiling, the colour is more or less removed, and a yellow solution is obtained. These tests may be applied either to the dry colour or paint.

Chrome greens are frequently sold as lime greens, for which purpose they are entirely unsuitable, since both constituents—chrome yellow and Prussian blue—are discoloured by the action of lime (see par. 56, *a*). Chrome greens are also frequently mixed with aniline greens (*i.e.*, green lakes prepared from coal-tar dyes), which are fugitive ; such admixtures, whilst they may make the green fuller and brighter, render it unsuitable for situations in which it has to stand prolonged exposure to light. The presence of aniline greens may be detected by boiling with water and filtering, or allowing to settle ; the liquid should not be coloured green. Frequently, in this test, the water acquires a slight green tinge due to very fine particles of colour suspended in it, which cannot on account of

their fineness be removed by filter paper, but will settle on long standing. If an aniline green is really present, the water generally becomes a good deep green. It is, however, possible to make aniline greens which do not dissolve in water ; all are, however, soluble in methylated spirit. Thus it is better to boil with methylated spirit and filter. If an aniline green is present, the spirit is coloured green. The above remarks, concerning a trace of suspended green colour not removable by filtering, also apply here. Note that, in boiling with methylated spirit, a small flame must be used and the mouth of the test tube kept well away from it, in order to prevent the vapour from taking fire. It is quite sufficient to hold the test tube well above the flame without actually touching it. These two tests may be applied either to dry colours or paints ; in the case of paints, after boiling with spirit and filtering, the spirit becomes turbid owing to the separation of dissolved oil on cooling ; if it be again boiled it is easier to see whether it has abstracted any colour.

Bronze greens, Quaker's greens, etc., are usually chrome greens containing black or

brown pigments. They may be examined for aniline green.

118. **Zinc Greens** are mixtures of zinc yellow and Chinese blue, more or less reduced. They are recognised by the following tests : On boiling with caustic soda they give a yellow solution and a slightly brown residue containing the reducing materials. When boiled with water they give a yellow solution. Also boil with a *little* strong hydrochloric acid, pour off the green or blue liquid and cool it ; no separation of crystals (lead chloride) should occur, and the liquid, when diluted with water and a drop of sulphuric acid added, should give no white precipitate, which would denote the presence of a (lead) chrome yellow. Zinc greens should always be tested for aniline greens (as above).

119. **Guignet's Green, Oxide of Chromium, Lime Green.**—This expensive pigment, which is the lime green *par excellence*, is characterised by great stability. It is not destroyed by heating in the flame, though its shade is spoiled. It is not attacked by boiling with caustic soda or with hydrochloric acid, and is thus easily recognised. Pure Guignet's green gives no colouration to the flame when heated

on platinum wire with hydrochloric acid; a green colouration would indicate the presence of barytes and a scarlet colouration the presence of Paris white. The absence of other green pigments is proved by boiling with water and spirit, which substances should not become coloured. Also boil with strong hydrochloric acid, dilute with water and filter; the solution should not have more than an exceedingly pale greenish tint. In the boiling no sulphuretted hydrogen should be given off (test with lead acetate paper as before, par. 103).

120. Green Ultramarine, Lime Green.—This permanent pigment, which is unattacked by lime, is easily recognised. When boiled with hydrochloric acid, it is converted into a white gelatinous substance, and sulphuretted hydrogen is given off, which may be recognised by the blackening of lead acetate paper. Green ultramarine should not colour boiling water or spirit and should be unattacked by caustic soda.

121. Aniline Greens, Green Lakes, Lime Greens.—The green lakes made from coal-tar dyes are used to make dry greens, green paints and lime greens. The presence of an aniline green in an especially bright green may always

be suspected. The aniline greens are not conspicuous for fastness and hence should be used with caution (see par. 55). It is necessary to examine aniline greens for shade and staining power, but there is no necessity as a rule to look for other greens, all of which are probably more valuable. The aniline greens are recognised by the green colour which they impart to water or spirit with which they are boiled (see above, par. 117). Their suitability for use as lime greens is recognised by their not giving up any colour (or the merest tinge) to boiling water and by the method given in par. 56, *a*.

122. **Míneral Green** is a copper green containing arsenic. It is recognised by the following tests: Boil a little of the powdered colour with dilute hydrochloric acid; it is readily and entirely soluble to a yellowish-green liquid. Heat a small quantity in the flame; it turns black. When heated on platinum wire with hydrochloric acid in the flame it gives a brilliant green flame. When caustic soda is added to a little of the powdered green, some dissolves giving a blue solution, which on boiling turns to a turbid brownish-yellow,

whilst the residue at the bottom turns black. On warming with ammonia, mineral green gives a deep blue solution. The purity of mineral green is most simply proved by means of its shade and staining power, aniline greens being first shown to be absent by means of the tests given above.

123. **Green Verditer** is a species of reduced mineral green. It is recognised by the same tests as mineral green, with the exception that it is not (as a rule) entirely soluble in hydrochloric acid. Green verditers are to be examined for shade, staining power and absence of aniline greens (par. 117).

124. **Emerald Green.**—This beautiful but extremely poisonous pigment is frequently adulterated, and since it is expensive, small adulterations are practised, which it is a matter of importance to be able to detect. There are also of course reduced qualities which are sold as such. Emerald green is recognised, in the dry state or in paints, by boiling with caustic soda solution, when it is converted into a very characteristic reddish compound, which at first renders the liquid turbid, but soon deposits. Also, when boiled

with dilute sulphuric acid, acetic acid is evolved, which is recognised by the smell (of vinegar). Like the other copper pigments, it gives a blue solution in ammonia. Emerald green is to be tested for shade, but cannot well be examined for staining power, since on grinding the colour becomes paler. However, a paint in which the emerald green is already ground may be examined for staining power in comparison with another paint of the same shade.

Emerald green is to be examined for the presence of aniline greens by the methods already given (par. 117). It is always advisable to test for these adulterants, which are very commonly used. Warm a small quantity of the dry green with dilute hydrochloric acid, a white powder (arsenic) separates at the surface of the liquid and dissolves on boiling. If the liquid is not then perfectly clear and free from sediment, allow to stand till the suspended matter settles, pour off the liquid, add more acid, boil again, let settle, pour off the liquid, then add water, let settle and pour off. The sediment is now to be examined by the flame test for barytes, which gives a pale green

colouration. Some care is necessary in performing this test, since emerald green itself gives a bright green flame, which might be mistaken for the barytes flame. The above method of washing out all soluble constituents leads to a reliable result if properly conducted.

Whilst a small quantity of barytes in emerald green may be found in this way, it is more difficult to detect terra alba, which is also used for this purpose. Dissolve a portion of the dry green in a little dilute hydrochloric acid, add water and then 2 or 3 drops of barium chloride solution; not more than a white cloudiness should result, any considerable deposit obtained on standing probably denotes the presence of terra alba.

RED PIGMENTS AND PAINTS.

125. The order in which the various red pigments are treated here is adopted for the sake of convenience; it appears better to deal first with the substances which are used for reducing and adulterating the pigments which follow.

126. *Vermilionettes* are the lakes of certain coal-tar dyes mixed with barytes, red lead,

orange lead, etc.; they are known under a variety of other names—royal reds, Turkey reds, etc., etc. Vermilionettes are recognised by boiling with water and methylated spirit, and allowing to settle or filtering; the water is coloured a more or less deep red, the spirit red or red with a characteristic yellow fluorescence (“bloom”). When heated in the flame the colour is destroyed (some burn violently) and a white or yellow residue is left. Vermilionettes are further examined for shade and staining power.

Vermilionettes are unfortunately often sold under the name of “permanent red”; a simple exposure for a few days (par. 55) is sufficient to test the permanence of a real vermillionette.

127. Permanent Reds, Vermilion Substitutes.—There are certain reds, also derived from coal tar, which are really permanent and capable in this respect of competing with genuine vermilion. The most important may be divided into two classes—“para” reds and alizarine reds. The former, though commonly sold as permanent, are not quite entitled, according to the writer’s experience, to the description, although they are very much more

durable than the vermilionettes ; the alizarine reds appear to be permanent to a sufficient extent for any decorative purpose and in some respects to excel vermilion. It is therefore important to be able to differentiate these two classes of permanent reds from one another and from the vermilionettes. The four following tests enable this differentiation to be easily made : (1) Boil a little of the dry colour or paint with water, and filter or let settle as stated above ; vermilionettes give a more or less deep red solution, para reds give a pale brownish or orange solution, and alizarine reds do not colour the water. (2) Boil the dry colour or paint with methylated spirit, filter, and heat to remove the turbidity. Vermilionettes give a bright red solution or red with a yellow "bloom," para reds give an orange-red solution, alizarine reds practically do not colour the spirit, at the most they give a very faint pink. (3) Boil the dry colour or paint with aniline oil (par. 46) in a dry tube and filter (allowing to settle is hardly sufficient in every case). Vermilionettes give a more or less purple-red solution, alizarine lakes give a pale brown tint, whilst para reds give

an intense orange-red solution, which is readily distinguished from the solutions given by vermilionettes if tests are made at the same time on samples of known composition. This is the main test by which para reds are to be recognised. (4) Boil the dry colour or paint with caustic soda solution. Vermilionettes give a red solution, or a red with a very strong green "bloom," para reds give a bluish-red solution, whilst alizarine reds yield a very deep violet solution, the colour of which is quite characteristic. By means of these tests it is easy to decide whether a so-called permanent red is entirely composed of para or alizarine red, whether it is entirely a vermilionette, or, finally, whether it consists mainly of a para or alizarine red "touched up" by vermilionette.

When it has been found that a permanent red contains only para or alizarine red, it remains simply to examine the shade, staining power, and covering power or body of the pigment. If the pigment is to be used for producing tints, the character of the shade obtained in testing the staining power is of great interest.

128. Vermilion is recognised by the fact that it is almost entirely volatile when strongly heated. Heat a little in the flame on an old knife or piece of tin; the vapours produced smell of burning sulphur, and finally only a very slight white ash is left. Heat a little of the powder in a small dry test tube; it volatilises and collects on the walls in a shining black deposit; a very slight residue is left. The vermilionettes and permanent reds leave a residue practically equal in volume to that of the original substance, when burnt in the flame. These tests also serve to determine the purity of a sample of vermilion. Pure vermilion should only leave the very slight residue on heating in the flame, and should yield up no colour to boiling water or methylated spirit, or to caustic soda; a coloured solution in these cases would show the presence of vermilionettes. Vermilion is probably more liable to be replaced by other reds than to be adulterated.

129. Red Lead, Orange Lead.—These pigments may be regarded as varieties of the same chemical compound differing in colour only. They are recognised by the following

tests : Boil a little of the powder with dilute nitric acid, a dark, brownish-red powder is left. Boil a little of the powder with strong hydrochloric acid ; it at once turns to a white crystalline mass, which dissolves when boiled with a large quantity of water.

The shade is to be examined, especially in oil. Dip a platinum wire in hydrochloric acid, then take up a very slight quantity of the powder on the wire and heat in the flame, again dip in hydrochloric acid, and heat, and continue until the flame is no longer coloured. No scarlet flashes should be seen in the flame, and no green colouration, which would denote admixture of terra alba or Paris white, and barytes respectively ; the flame should be coloured the peculiar pale blue given by compounds of lead (and other metals). Place a little of the powder in a test tube and boil with strong hydrochloric acid ; when the colour is pure white, add water, boil, let settle for a moment, and pour off the liquid ; then add more water, boil, and again pour off. Repeat this treatment so long as small, white crystals remain. If, finally, there is a white residue, which will not dissolve, it is probably barytes,

and is to be tested in the flame on platinum wire (green colouration). Red lead is frequently adulterated or reduced by means of a very common vermilionette, the presence of which is detected (see par. 126) by boiling with water and methylated spirit, neither of which is coloured by pure red or orange lead. Red lead paint (if required pure) may be tested simply by the flame test on platinum wire, as described at the beginning of the paragraph.

130. Venetian Red, Indian Red, Red Oxides.—The colouring constituent of these reds is the oxide of iron which is known to chemists as ferric oxide. The various shades are due to different conditions of the same oxide. These reds are recognised by giving a yellow solution when boiled with strong hydrochloric acid, which solution, after adding much water, gives a blue colouration or precipitate on adding a solution of potassium ferrocyanide (yellow prussiate). In order to apply this test to paints, they must first be burnt or the oil extracted (par. 98).

The natural red oxides, in addition to the oxide of iron, contain earthy matter, so that

there is no object in testing for impurities, which are naturally present. Indian red is examined for purity by means of the flame test, no green or scarlet colouration should be obtained ; it is also to be very finely powdered (paint would be first burnt), and a small quantity placed in a small beaker standing on wire gauze, strong hydrochloric acid is then added, the beaker covered with a watchglass and the acid boiled for a long time by means of a small flame, so that little or no acid fumes escape, until the red entirely dissolves or the residue appears to be white. Pure Indian red should dissolve entirely ; any residue, which indicates impurity, may be tested on platinum wire in the flame. If purity is not requisite, it is simply necessary to examine the shade and staining power.

Certain red oxides, both the dry colours and paints, generally known as maroons and Tuscan reds, contain, in addition to the oxide, red lakes, which impart a brighter and deeper shade. The presence of para and alizarine reds can be detected by means of the tests given in par. 127. If the dry colour or paint, when boiled with water, colours it red, the colour or paint

contains some red lake more fugitive than a permanent red, which would show that the deep red shade would more or less soon be lost on exposure to sunlight. The tests for these lakes are obscured by the presence of the oxide of iron.

131. Persian Red, Chinese Red.—These red pigments consist of a basic chromate of lead and are thus similar in composition to orange chromes. They are identified by boiling with strong hydrochloric acid, when a green solution is obtained and white crystals of lead chloride are deposited on cooling. A practical test for Persian and Chinese reds depends on the fact that the colour is destroyed by grinding—pass a palette knife several times heavily over a small quantity of the colour on a piece of paper, if it turns yellow the pigment is a red of this class. Persian and Chinese reds mixed with a fair proportion of vermilionette do not behave in this manner. In consequence of this behaviour, it is necessary to treat these reds gently when examining them for shade both dry and in oil, and it is impossible to test the staining power in the ordinary way.

The usual adulterants of Persian and Chinese reds are red (or orange) lead and vermilionettes. An admixture of a pure orange chrome could hardly be described as adulteration, since it would alter the shade but (practically) not the composition of the pigment. Red lead and orange lead can be detected by the methods given for detecting red lead in orange chromes (par. 106). When a small quantity of the red is boiled with strong hydrochloric acid, water added, the mixture again boiled, allowed to settle and the clear liquid poured off, and this process repeated, there should finally be no residue. Any sediment is to be tested on platinum wire in the flame; a white sediment which gives a green colouration indicates the presence of barytes, which probably denotes the addition of a vermilionette. Boil a portion of the sample with water and with methylated spirit and filter, neither liquid should be coloured (see par. 126).

132. Rose Pink is the lake obtained from a dye-wood. It differs from the lakes which are present in vermilionettes in not colouring methylated spirit, but it yields a red solution when boiled with water.

BROWN PIGMENTS AND PAINTS.

133. Siennas, Umbers, Vandyke Brown.—

These pigments, and the paints made from them, are to be examined for fineness of grinding, shade and staining power. The shade obtained in testing the staining power is of great importance; the brighter and prettier it is in each case, the better the pigment or paint. These practical tests are all-important. It is, as a rule, unnecessary to conduct any further examination.

BLACK PIGMENTS AND PAINTS.

134. Ivory Black, Drop Black, is the pigment produced by heating bones in a closed vessel. It is recognised by burning it in the flame, when it leaves a considerable ash, almost white in colour, which dissolves easily on warming with a little dilute hydrochloric acid, without any noteworthy evolution of gas. If ammonia be added to the solution in small quantities at a time until a precipitate is obtained, then acetic acid (in excess) to dissolve the whole of the precipitate (except a few insignificant flocks), and, finally, uranium acetate

solution, a yellow precipitate is obtained, which is not formed unless real ivory black was originally present. This test would not discover the addition of other black pigments to ivory black. Ivory black is to be examined for shade and staining power.

135. **Lamp Black, Vegetable Black, etc.**—In the case of black pigments other than ivory black, it is less a question of the material from which the black was made, or its present composition, than of its shade, staining power and the character of the tones it produces on reduction with white lead, all of which are to be examined. Pure lamp black and vegetable black should leave no residue when burnt in the flame on a piece of tin ; mineral black on the other hand may leave a somewhat considerable residue. No black pigment should contain a large amount of oil or tar, which may interfere unduly with the drying of the paint, and produce a curious, bronze-like effect on the surface of the dried paint. It is easy to find the quantity of this oil in a dry lamp black. Weigh 2 grams of the black, transfer to a large test-tube ($6 \times \frac{3}{4}$ in.), and add ether, warm the tube for a few minutes in a vessel of warm

water at a distance from a flame, taking care that the ether only boils very slowly. Then filter through a dry paper and catch the ether in a weighed basin, add more ether to the black which remains in the tube, warm in the same manner and filter through the same paper into the dish. Now float the dish in a vessel of warm water until the ether has nearly all evaporated, finish the evaporation over a beaker of boiling water, let the dish cool and weigh again. The increase in weight of the dish, multiplied by 50, gives the percentage of oil in the black. The method as described is rough, but gives a result which is of practical importance. The maximum amount of oil permissible in a lamp black may be fixed by examining in the same manner a sample which is found to be satisfactory in practice. It should probably not exceed 2 to 3 per cent.

Whether unburnt oils are present in black pigments or not, they have a marked effect in preventing the drying of paints in which they are used. It appears that even chemically pure carbon prevents boiled oil from drying. The effect of any particular sample of black can be examined as described in par. 57.

OIL VARNISHES.

136. It has been already stated that it is not yet possible to ascertain the particular gum (resin) which is contained in an oil varnish, and on which the wearing qualities of the varnish largely depend. Certain resins, however, give some indication of their presence. Kauri resin imparts a reddish stain to a varnish; damar resin can be detected by its smell, if present in considerable quantity, especially in the dried varnish. The latter resin should certainly not be found in a varnish intended for outside use. The presence of common rosin, which is objectionable in most varnishes, can, however, be more or less easily detected. Shake a small quantity of the varnish, which is to be tested for rosin, with an equal volume of strong ammonia violently for a minute or two. If a large quantity of rosin is present, the varnish at once sets to a solid lump; if a smaller quantity is present the varnish may only separate a few small solid lumps. If no solidification occurs, let the mixture stand for two hours; it should then still be in such a condition that it can be

again shaken or stirred up to a uniform mixture, and should show no signs of solidification. This test does not always reveal the presence of rosin; the method given in the following paragraph is more reliable.

137. Put 100 c.c. of methylated spirit in a 10 oz. beaker. Take a small lump of sodium¹ out of the mineral naphtha in which it is kept (par. 35), dry it with filter paper, cut off the crust from all sides of the lump to expose a perfectly clean surface of metal. Then rapidly weigh exactly 0.76 gram, cutting off or adding small portions until the exact weight is obtained. This operation must not take much time. At once throw the sodium into the methylated spirit, cover the beaker with a

¹ *Cautions concerning the use of Sodium.*—Sodium must not be allowed to come in contact with water or any moist substance. It may be held in the dry fingers and cut with a clean knife, which must afterwards be washed with water or it will rust. The scraps of sodium cut off from the outside of the lump are best disposed of by throwing them, not too much at a time, into methylated spirit, which is thrown away when all action is over. If a piece of sodium comes in contact with water, a violent action takes place, accompanied by a hissing noise, finally a slight explosion takes place and small particles may be projected to some distance. If such an accident occurs, stand well away until the explosion has occurred, to avoid risk of injury.

clock-glass and place it in a vessel of cold water, taking care that no water enters the beaker. In a short time the sodium dissolves and there is obtained a solution of caustic soda, of a definite strength, in methylated spirit. This solution is to be kept in a well-stoppered bottle; it is not advisable to keep it too long, say for more than six months.

Weigh 1 gram of the blue dye known as Alkali Blue (par. 49), transfer to a flask and add 100 c.c. of methylated spirit. Warm gently; when the dye appears to have dissolved let the solution cool, and filter it through a dry filter paper into a dry bottle.

By means of these two solutions the test may now be performed. Measure 10 c.c. of the varnish (which is assumed to be of an ordinary consistency; if not, it must be brought to the proper consistency, or a correspondingly larger or smaller quantity taken according as the varnish is thin or round) in a 10 c.c. measure. Pour into a small flask or bottle, then put 10 c.c. of rectified benzol into the measure, shake well with the thumb over the end until the varnish on the sides is dissolved and add to the varnish in the flask; repeat this

with a second 10 c.c. of benzol. Then shake the liquid in the flask round and round until the varnish on the bottom is entirely dissolved, which may take some little time, add now 20 c.c. of methylated spirit and 5 c.c. of the solution of Alkali Blue, shake round and then add 8 c.c. of the solution of sodium in methylated spirit. (The burette is the proper measuring instrument for this purpose.) Shake well and observe the colour. If the mixture is red, rosin is absent; if it is green, rosin may be present. Add 1 c.c. more of the sodium solution and shake again, if the mixture now turns red, probably rosin is absent, or if the varnish contains it, it is only present in small quantity. Continue to add the sodium solution in quantities of 1 c.c. at a time, shaking after each addition, until the green colour finally changes to red. Some idea of the quantity of rosin varnish present may be found from the volume of sodium solution requisite to produce the red colouration. A varnish made from rosin alone might require anything from 20 to 50 c.c. of sodium solution, according to the manner in which it was made.

SPIRIT VARNISHES.

138. French Polish and Knotting Varnish.

—It is not easy to judge of the consistency of these varnishes by the ordinary methods which are applied to thicker varnishes. Their quality depends on the presence of the proper resin (shellac) or resins, and on the quantity of the resin. By means of the following methods it is easy to find the exact quantity of resin present in the varnish, and also to ascertain whether the resin is pure shellac.

Clean and weigh a small evaporating basin together with a glass rod of suitable length. Measure 10 c.c. of the varnish, run it into the dish and allow the measuring cylinder to drain, then put into it a few c.c. of methylated spirit, shake thoroughly and transfer the spirit to the dish. Put the dish on the top of a beaker of water standing on wire gauze supported by a tripod stand, and place a small wedge of paper between beaker and dish so that the steam may have space to escape. Boil the water gently and stir the varnish from time to time, continue this until the varnish becomes stringy in the dish, and on cooling is

found to be quite hard and free from all smell of spirit. When cold weigh the dish again. The increase in weight gives the weight of resin, in grammes, in 10 c.c. of the varnish, the same number gives the weight in lbs. in 1 gallon.

Next in order, to ascertain whether the resin is pure shellac, measure 10 c.c. of the varnish, run into a small clean dry flask, shake a few c.c. of methylated spirit in the measure and add to the varnish, add 20 c.c. more spirit, 5 c.c. of Alkali Blue solution (par. 137), and a certain volume of the solution of sodium in methylated spirit (par. 137), which volume is to be calculated as follows : Multiply the weight of the resin obtained by evaporating 10 c.c. of the varnish (last paragraph) by 4·1, the product is the number of c.c. of sodium solution to be used. Thus, supposing that 10 c.c. of varnish gave 2·25 grams of resin, we should add $2·25 \times 4·1 = 9·2$ c.c. of the solution of sodium. After adding the sodium solution, shake well ; if the solution remains red, the shellac is probably pure. If the solution is greenish or blue, other resins (or rosin) are present. Continue to add the sodium solution in quantities of

$\frac{1}{2}$ c.c., shaking after each addition until the colour changes to red. Then, assuming that rosin is the adulterant, we may calculate the percentage present in the total resin as follows: 1 gram of rosin would require about 9 c.c. of the sodium solution, 1 gram of pure shellac requires 4.1 c.c. To take an example: If 10 c.c. of French polish contained 2.1 grams of resin and 10 c.c. required 12 c.c. of the sodium solution, then 1 gram of the resin requires $\frac{12}{2.1} = 5.7$ c.c. of the sodium solution, and the percentage of rosin in the total resin is $\frac{5.7 - 4.1}{9 - 4.1} \times 100 = \frac{1.6}{4.9} \times 100 = 33$ (nearly).

LINSEED OIL.

139. We have previously seen that an estimation of the specific gravity of raw and refined linseed oil enables adulteration with mineral oils or rosin oil to be detected, if the added quantity is fairly great, and that adulteration of boiled oil may also be indicated in the same manner. This test, however, fails to reveal the presence of small amounts of mineral oil, say 2 to 4 per cent., which quantities would, at present prices, make a considerable difference between the

value of genuine linseed oil and the mixture. The following test enables the presence of 2 per cent. of mineral oil to be detected with absolute certainty in either raw, refined, or boiled oil, and gives rise to suspicions in the case of 1 per cent. It is, however, very easy to obtain a false result if all the directions given are not exactly followed. Thoroughly clean a test tube, finally washing it out with distilled or condensed water, then dry it with a clean cloth. Break up a small piece of stick caustic potash in a mortar, and transfer a small fragment to the test tube, add 5 to 10 c.c. of absolute alcohol (methylated spirit will not do), and warm, just bringing to the boil. Then drop into the tube from a small bottle, or from a glass rod, exactly three drops of the oil to be tested (not more), and let the oil fall down into the alcohol without running down the walls of the tube. Then boil over a small flame, keeping the bottom of the tube at some distance above the flame as soon as boiling commences. Let the alcohol boil gently in this manner for two minutes by the clock, without allowing much vapour of spirit to escape from the tube, when

it might easily take fire. After boiling for two minutes add an equal volume of hot distilled water, which should be run straight into the alcohol and as far as possible not down the sides of the tube. The mixture should be perfectly clear without any sign of turbidity. If the linseed oil contains 2 per cent. of mineral oil, there is a very marked turbidity, while 1 per cent. of mineral oil causes a distinct opalescence. If an oil once gives a clear solution in this test, it is undoubtedly free from mineral oil and rosin oil. Errors and mishaps in executing the test all lead to a turbid solution in the end, and thus to a possibly erroneous assumption of the presence of mineral oil. The beginner should try this test on oil which is known to be pure, until he can obtain the proper result without fail. Indeed, it is never advisable to trust the result of a single test, since there are so many possible sources of error. When a test indicates the presence of adulterated oil, some idea of the extent of the addition of mineral oil may be obtained by making tests on oil containing known percentages of mineral oil and comparing the turbidities.

Given that a sample of linseed oil (raw, refined, or boiled) is genuine, its quality is judged by means of the way in which it dries (pars. 91, 92, 93). The quality of raw linseed oil—whether it is Baltic or ordinary—is best estimated by means of the iodine value, which requires the attention of a trained chemist.

TURPENTINE.

140. Turpentine which has the proper specific gravity is probably pure; if the specific gravity is low, it is probably adulterated with some variety of mineral spirit. In order to confirm the indications of the specific gravity and to some extent to find the quantity of mineral spirit present, we may determine the solubility of the sample in methylated spirit. Carefully measure 10 c.c. of genuine turpentine and transfer to a flask or small bottle (a stoppered bottle is best), add 35 c.c. of methylated spirit, also carefully measured (from a burette, if possible), and shake well. A clear solution will not be obtained. Then add spirit in quantities of 1 c.c. and shake well after each addition until finally a clear solution

is obtained. Then take another 10 c.c. of genuine turpentine, add 1 c.c. less spirit than the total quantity used in the last experiment and shake well, the solution should be nearly clear; then add spirit half a c.c. at a time until the solution is quite clear. Thus the exact quantity of spirit required to dissolve 10 c.c. of genuine turpentine is found. Now measure 10 c.c. of the sample of turpentine under examination, add the quantity of spirit which was required by 10 c.c. of genuine turpentine and shake: if a clear solution is not obtained, the sample is adulterated; add spirit 1 c.c. at a time, shaking after each addition, until the clear liquid is obtained. Then repeat this operation on various mixtures of genuine turpentine and "patent turpentine," in order to find a mixture which requires the same volume of spirit as the adulterated sample; this mixture will have a composition somewhat the same as the sample.

It is to be observed that the solubility of turpentine in spirit varies with the strength of the spirit and the temperature, so that it is necessary to find the quantity of spirit required by genuine turpentine on each oc-

casion when the test is performed. Also this method cannot be applied to mixtures of turpentine and "patent turpentine" in which the latter preponderates (see also par. 94).



THE END.

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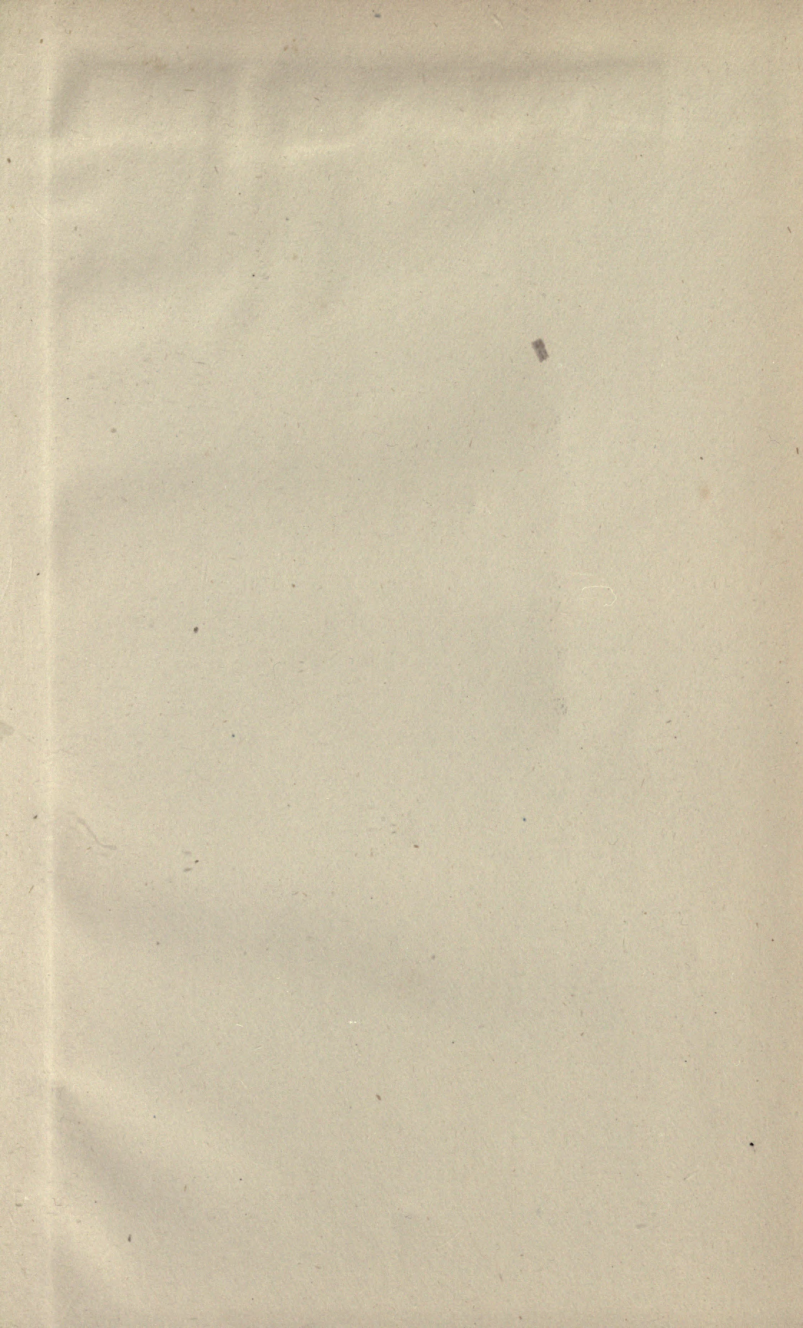
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